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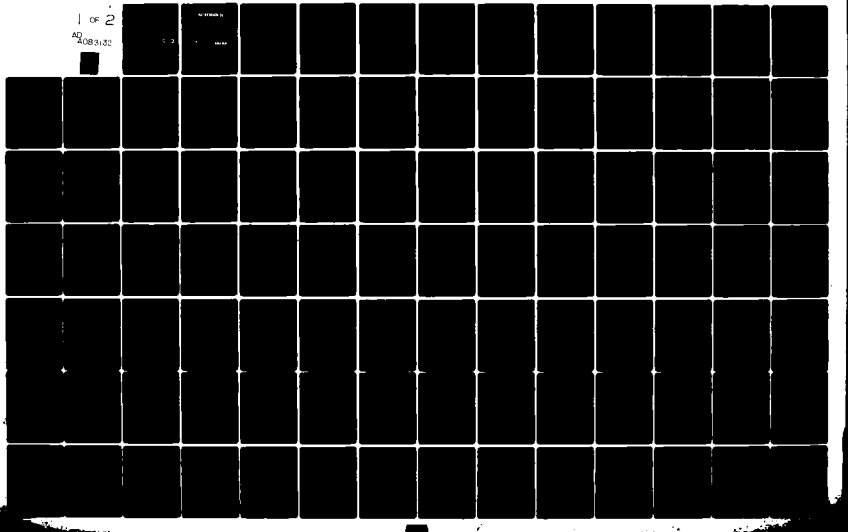

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This document details the link level protocols supported by the Initial Operational Capability configuration of the AUTODIN II Terminal Access Controller. It provides specific protocol rules and formats for the AUTODIN II link level Modes I, IB, IIA, and VI.

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ILLUSTRATIONS

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ABBREVIATIONS

ABM	Asynchronous Balanced Mode
ACK1	Acknowledgment No. 1
ACK2	Acknowledgment No. 2
ADCCP	Advanced Data Communication Control Procedure
ANSI	American National Standards Institute
ASCII	American Standard Codes for Information Interchange
BA	Balanced Asynchronous
BCC	Block Check Character
BP	Block Parity
BSC	Binary Synchronous Communications
BSL	Binary Segment Leader
CAN	Cancel
CAU	Crypto Ancillary Unit
DCE	Data Communication Equipment
DEL	Delete
DTE	Data Terminal Equipment
EM	End of Medium
ENQ	Enquiry
EOT	End of Transmission
ETB	End of Transmission Block
ETX	End of Text
F	Flag Sequence, Final Bit
FCS	Frame Check Sequence
FDX	Full Duplex
FRMR	Frame Reject
I	Information Frame, Command
ICU	Interface Control Unit
INV	Suspected Invalid Message
ITB	Intermediate Transmission Block
LCM	Line Control Module
LTU	Line Termination Unit
NAK	Negative Acknowledgment
N(R)	Receive Sequence Number
N(S)	Send Sequence Number
P	Poll Bit
P/F	Poll/Final Bit
PSN	Packet Switching Node
REP	Reply
RM	Reject Your Message
RNR	Receiver Not Ready
RR	Receiver Ready
RSET	Reset
S	Supervisory Frame, Command
SABM	Set Asynchronous Balanced Mode
SCM	Switch Control Module
SEL	Select
SOH	Start of Header
SS	Supervisory Commands for S Frames
SYN	Synchronous Idle
STS	Start of Test
STX	Start of Text
TAC	Terminal Access Control

TDM	Time Division Multiplexer
TDMI	Time Division Multiplexer Interface
TWS	Two-Way Simultaneous
U	Unnumbered Frame, Command
UA	Unnumbered Acknowledgment
UI	Unnumbered Information
WBT	Wait Before Transmitting

SECTION 21 - INTRODUCTION

The purpose of this document is to describe specific AUTODIN II data formats and protocols supported by the Packet Switching Node (PSN). The data presented has been extracted from various sources (see Section 22) and reflects PSN data support requirements.

21.1 PURPOSE. This document details the protocols and data formats being supported by the PSN software. The document is intended to provide specific information describing external data protocols, header formats, and user interface requirements.

21.2 SCOPE. This document identifies header formats, frame formats, and protocol requirements for external PSN data sources. The document does not describe intra-PSN data requirements nor does it detail error cases in or out of the PSN.

21.3 CONTENT. The document is organized in six primary sections:

a. Section 22 identifies documents which provide the basis for this document

b. Section 23 describes Mode VI data requirements

c. Section 24 describes Mode I data requirements.

d. Section 25 describes Mode IB data requirements

e. Section 26 describes Mode IIA data requirements

f. Section 27 describes THP command procedures to be used with terminal heading data.

SECTION 22 - APPLICABLE DOCUMENTS

The following documents were used to generate the various data formats:

a.	DCAC 370-D175-1 02 October 1970	DCS AUTODIN Interface and Control Criteria, Chapters 1, 3, 4 and 5.
b.	IBM Order No. GA27-3004-2 October 1970	Binary Synchronous Communications, 3rd Edition
c.	ANSI X3.28-1971 (American National Standards Institute) 10 March 1971	Procedures for the Use of Communication Control Characters of American National Standard Code for Information Interchange in Data Communications Links
d.	FIPS PUB 1 01 November 1968	Federal Information Processing Standards Publication 1 - Standard Code for Information Interchange
e.	ANSI X3S34/589 (American National Standards Institute) Revision 2 11 August 1977	Sixth Draft: American National Standard for Advanced Data Communications Control Procedures (ADCCP), Independent Numbering

f. AUTODIN II Mode VI (ADCCP) Line Control Procedures Functional Specification dated 02 May 1978

g. AUTODIN II Segment Interface Protocol (SIP), Specification, WU System Engineering Technical Note 78-07.2, dated 03 October 1978.

h. System Performance Specification for AUTODIN II Phase I, November 1975, as amended through Amendment 0006, dated 13 October 1976.

i. Final Computer Program Development Specification, MCCU THP, CDRL Item Number B006, 29 September 1978.

SECTION 23 - MODE VI - LINK PROTOCOL

23.1 INTRODUCTION. The AUTODIN II system will use the American National Standards Institute (ANSI), document X3S34/589-Advanced Data Communication Control Procedures (ADCCP) Independent Numbering, Draft 6, Revision 2, for line control on backbone (packet switch-to-packet switch) and Mode VI access (subscriber-to-packet switch) circuits. AUTODIN II ADCCP will use the Balanced Asynchronous (BA) class of procedures. The basic mode of operation is Asynchronous Balanced Mode (ABM) with all stations supporting two-way simultaneous (TWS) operation.

23.2 APPLICABLE DOCUMENTS

a. ANSI Document X3S34/589, Draft 6, Rev. 2, Advanced Data Communication Control Procedures (ADCCP)

b. AUTODIN II Mode VI (ADCCP) Line Control Procedures Functional Specification dated 2 May 1978

23.3 FRAME FORMAT. ADCCP transmissions are packaged into distinct sets of binary data called frames. The ADCCP data frames are given in Figure B-1. The frames contain the following:

a. Flag Sequence (beginning) (8 bits)
b. Address Field (8 bits)
c. Control Field (8 bits)
d. Information Field (0 to a maximum of 5072 bits)
e. Frame Check Sequence (32 bits)
f. Flag Sequence (Ending) (8 bits)

The Information (I) frame is used to perform an information transfer. The Supervisory (S) frame is used to perform link supervisory control functions such as acknowledgment of I frames, and informing subscribers that a temporary interruption has occurred at the receive terminal. The Unnumbered (U) frame is used to provide additional link control functions. This format contains no sequence numbers. Refer to paragraph 23.13 for the Mode VI Data Formats.

23.3.1 Flag Sequence. The flag sequence (F) is a unique series of eight bits called an octet. This is a single octet field which always contains the binary value 01111110. All frames start and end with the flag sequence. Receive Line Termination Units (LTU's) search for the flag sequence on a bit-by-bit basis. When found, frame synchronization is established. The ending flag sequence of a frame may not serve as the beginning flag sequence of the succeeding frame. Transmitting LTU's generate the flag sequence at the beginning and end of each frame.

1. INFORMATION (I) FRAME FORMAT

FLAG (F) 01111110	ADDRESS (A)	CONTROL FIELD				INFORMATION FIELD (MAXIMUM 5072 BITS)	FRAME CHECK SEQUENCE (FCS)	FLAG (F) 01111110
		0	N/S	P/F	N(R)			

COMMAND	RESPONSE
I	I COMMAND FRAME, RR, RNR, FRMR

2. SUPERVISORY (S) FRAME FORMAT

FLAG (F) 01111110	ADDRESS (A)	CONTROL FIELD				FRAME CHECK SEQUENCE (FCS)	FLAG (F) 01111110
		10	SS	P/F	N(R)		

COMMAND	RESPONSE
RR(00)	RR(00), RNR(10), FRMR(U:10001)
RNR(10)	RR(00), RNR(10), FRMR(U:10001)

3. UNNUMBERED (U) FRAME FORMAT

FLAG (F) 01111110	ADDRESS (A)	CONTROL FIELD				INFORMATION FIELD (MAXIMUM 5072 BITS)	FRAME CHECK SEQUENCE (FCS)	FLAG (F) 01111110
		11	$M_1 M_2$	P/F	$M_3 M_4 M_5$			

COMMAND	RESPONSE
(NO INFO FIELD) SABM(11100)	UA(00110), FRMR(10001)
(INFO FIELD) UI(00000)	UA(00110), FRMR(10001), UI(00000), RNR(S:01)
(NO INFO FIELD) RSET(11001)	UA(00110), FRMR(10001)

NOTE:
THE BINARY VALUES IN PARENTHESIS INDICATE:
1. FOR RR, RNR: VALUE OF SS
2. FOR SABM, UI, UA, FRMR, RSET: VALUES OF M1, M2, M3, M4, AND M5 IN ORDER

Figure 3-1. Mode VI Frame Formats

There is a possibility that a frame may contain a bit pattern in the Address, Control, Information and Frame Check Sequence (FCS) fields which duplicates the flag sequence. If this condition occurs, the LTU logic performs 0 bit insertion following five contiguous one bits (on transmit) and deletion (on receive) to ensure the uniqueness of the flag sequence. The receiver continuously monitors the received bit stream. Upon receiving a zero (0) bit followed by five (5) contiguous one bits, the receiver inspects the following bit:

a. If a zero (0), the five (5) one bits are passed as data and the zero bit is deleted.

b. If the 6th bit is a one (1), the receiver inspects the 7th bit as follows:

   1. If it is a zero (0), a flag sequence has been received

   2. If it is a one (1), an abort has been received. See paragraph 23.10.6.

23.3.2 Address Field. The address field consists of one octet, 8 bits. This allows for a maximum of 0-255 unique address per station. This field contains the address of either the local or remote station, and is used by the receiving station to identify incoming frames, either command or response frames. The address field in a command frame contains the address of the remote (receiving) station; the address field in a response frame contains the address of the local (transmitting) station.

23.3.3 Control Field. The control field consists of one octet, 8 bits. This field contains link control information such as commands, responses, and send/receive sequence number information. The bit sequence for each of the frames is as follows:

0 = Information Frame
10 = Supervisory Frame
11 = Unnumbered Frame

a. N(S) - Send Sequence Number. The send sequence number is three bits, 0 through 7 (Modulo 8). The N(S) is the sequence number of the transmitted information frame. The send sequence number is incremented by one with each completed I frame transmission. N(S) will not be incremented when an I frame transmission is aborted.

b. N(R) - Receive Sequence Number. The receive sequence number is three bits, 0 through 7 (Modulo 8). The N(R) is the expected sequence number of the next received I frame and appears only in information (I) and supervisory (S) frames. The N(R) value informs the transmitting station that the receiving station has correctly received all I frames numbered up to and including N(R)-1.

c. P - Poll Bit. The poll bit set to a 1 is used to solicit a response from a receiving station. In AUTODIN II, all commands request a response regardless of Poll Bit setting.

d. F - Final Bit. The final bit is set to respond in reply to the receipt of a set poll bit in a received frame. In AUTODIN II, the F bit in all response frames assumes the state of the P bit in the command frame which provoked the response.

e. SS - Supervisory Commands for S Frames. The two bit supervisory commands and responses are used to perform basic supervisory link control functions such as I frame acknowledgment and indicate a temporary interruption to receive I frames. The supervisory commands/responses used in AUTODIN II are described in paragraphs 23.4.2 and 23.5.1. The values for the bit positions are defined in Figure B-1.

f. M1 through M5 - Modification Bits for U Frames. These five bits in U frames allow definition of up to 32 additional command/response functions. The commands/responses used in U frames are described in paragraphs 23.4.3 and 23.5.2. The values for the bit positions are defined in Figure B-1.

23.3.4 Information Field. This field contains the actual information being transmitted over a link. The field size is variable and ranges from 0 to a maximum of 5072 bits on access lines and 5168 bits on backbone links. The information field may contain a packet header, binary segment leaders (BSL) and other levels of higher protocols. The contents of the information field is transparent to the AUTODIN II system.

23.3.5 Frame Check Sequence (FCS). The Frame Check Sequence is 32 bits (four octets). This field uses a 32nd degree polynomial for error detection purposes. The contents of the Address, Control and Information Fields, excluding the zeros inserted, are included in the calculation of the Frame Check Sequence.

23.4 COMMANDS

23.4.1 Information (I) Commands. I frames are considered commands when they contain the address of the remote station. In AUTODIN II, all I frames are sent as commands. All I frames must be acknowledged.

23.4.2 Supervisory (S) Commands. AUTODIN II implements two S commands to perform supervisory link control:

a. Receiver Ready (RR) Command. The RR command is used to solicit a response from the remote station while indicating that the receiver is ready at the local station. In the AUTODIN II system, all RR commands must be answered with either an RR or Receiver Not Ready (RNR) response.

During periods of link inactivity, RR or RNR commands will be interjected at periodic intervals to ensure that the link is operating properly.

b. Receiver Not Ready (RNR) Command. The RNR command is used to solicit a response from the remote station while indicating the local station receiver is busy. In the AUTODIN II system, all RNR commands must be answered with an RR or RNR response. During periods of link inactivity, RR or RNR commands will be interjected at periodic intervals to ensure that the link is operating properly.

23.4.3 Unnumbered (U) Commands

23.4.3.1 Mode-Setting Command

Set Asynchronous Balance Mode (SABM) Command. the SABM command instructs the receiving station to reset all receive and transmit parameters and prepare to respond in the aynchronous balanced mode. Since AUTODIN II links always operate in the asynchronous balanced mode, the SABM serves only as a reset. Upon receipt of a SABM command, the send and receive sequence number variables are set to zero, existing error conditions are cleared, and the sequence number of the next expected frame (N(R)) is set to zero. The SABM command frame has no information field. SABM commands are acknowledged via the unnumbered acknowledgment (UA) response.

23.4.3.2 Information Transfer Command

Unnumbered Information (UI) Command. The UI command permits the exchange of information fields without sequence number accountability. The UI command is acknowledged by either UA, UI, or RNR responses.

23.4.3.3 Recovery Commands

Reset (RSET) Command. The RSET command causes the receiving station to reset all receive related parameters. Upon receipt of this command, the receive sequence number variable is set to zero, all existing receive error conditions are cleared, and the sequence number of the next expected frame (N(R)) is set to zero. RSET commands are acknowledged with a UA response. The primary use of the RSET command within the AUTODIN II system is during frame sequence number error recovery. The RSET command frame has no information field.

23.5 *RESPONSES*

23.5.1 Supervisory (S) Responses. AUTODIN II implements two S responses. They are used to acknowledge I command frames in certain instances, acknowledge receipt of S commands, and report certain error conditions.

a. Receiver Ready (RR) Response. RR responses are used to report the nonbusy status of a receiving station. They also acknowledge receipt of all I command frames having sequence numbers less than that reported as the next receive sequence number in the RR response frame control field. If a receiving station is not transmitting I command frames, the RR response is used to acknowledge receipt of I frames, provided the receiving station is nonbusy. RR responses are also required as acknowledgments for RR or RNR commands, provided the receiving station is nonbusy.

b. Receiver Not Ready (RNR) Response. RNR responses are used to report the busy status of a receiving station. They also acknowledge receipt of all I command frames having sequence numbers less than that reported as the next receive sequence number in the RNR response frame control field. If a receiving station is not transmitting I command frames, the RNR response is used to acknowledge receipt of I frames, provided the receiving station is busy. RNR responses are also required as acknowledgments for RR or RNR commands, provided the receiving station is busy.

23.5.2 Unnumbered Responses

a. Unnumbered Information (UI) Response. The UI response permits the exchange of information fields without sequence number accountability and is used in conjunction with the UI command (see paragraph 23.4.3.2).

b. Unnumbered Acknowledgment (UA) Response. UA responses are used to acknowledge receipt of SABM, UI, and RSET commands. The UA response has no information field.

23.5.3 Error Recovery Response

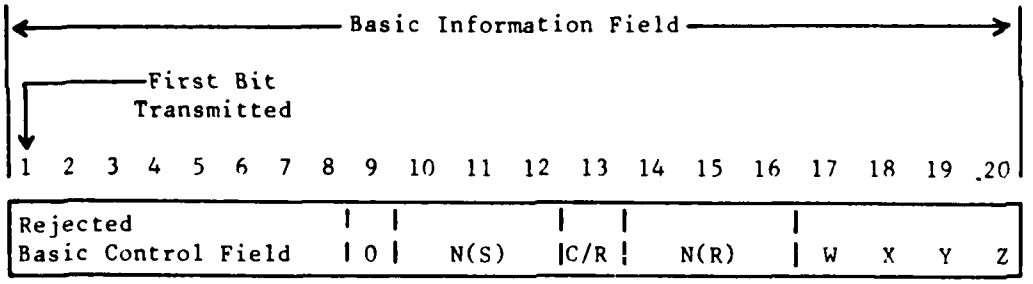
23.5.3.1 Frame Reject (FRMR) Response. The FRMR response is used to report error conditions which are not recoverable by retransmission of the errored frame. FRMR is generated by the following conditions:

a. Receipt of an invalid command or response.
b. Receipt of an I or UI frame which contains an information field which exceeds the maximum length.
c. An invalid frame format, eg, a frame which does not conform to the structure implied by the Command/Response contained in its control field in accordance with the "AUTODIN II, Mode VI (ADCCP) Line Control Procedures Functional Specification," dated 02 May 1978.

In the FRMR response, the status field provides the reason for the Frame Reject Response. The format and contents of this status field are shown below as the FRMR Basic Information Field.

FRMR Basic Information Field

A basic information field, which immediately follows the basic control field, is returned with this response to provide the reason for the Frame Reject response. The format for the basic information field is:



Where:

Rejected Control Field is the control field of the received frame which caused the frame reject exception condition.

N(S) is the current Send Variable (S) at the station transmitting the FRMR response.

C/R is set to "1" if the frame which caused the FRMR was a response frame, or is set to "0" if the frame that caused the FRMR was a command frame.

N(R) is the current Receive Variable (R) at the station transmitting the FRMR response.

W set to "1" indicates the control field recevied and returned in bits 1 through 8 was invalid or not implemented.

X set to "1" indicates the control field received and returned in bits 1 through 8 was considered invalid because the frame contained an information field which is not permitted with this frame. Bit W must be set to "1" in conjunction with this bit.

Y set to "1" indicates the information field received exceeded the maximum established capacity of the Secondary/Combined station.

Z if set to "1" indicates the control field received and returned in bits 1 through 8 contained an invalid N(R) number.

If required, the information field associated with the FRMR may be padded with zero bits so as to end on any convenient, mutually agreed upon character, byte, word or machine-dependent boundary.

FRMR may have bits W, X, Y, and Z all set to zero; however the cause for frame reject shall be as defined in a, b and c above.

23.6 COMMAND/RESPONSE SUMMARY. AUTODIN II Mode VI links will use the following command/response repertoire:

Command	Valid Responses
I	I Command Frame RR, RNR, FRMR
RR	RR, RNR, FRMR
RNR	RR, RNR, FRMR
SABM	UA, FRMR
UI	UA, UI, RNR, FRMR
RSET	UA, FRMR

23.7 INITIALIZATION REQUIREMENTS. AUTODIN II ADCCP links are initialized when the local station transmits a U frame containing the SABM (Set Asynchronous Balanced Mode) command. All service requests will be denied until the local ADCCP station receives a UA response to the SABM command. Upon receipt of the UA response, the local ADCCP station will initialize its variables and data structures; the local send and receive sequence number variables will be set to zero, and normal operation may commence.

23.8 ACKNOWLEDGMENT REQUIREMENTS. AUTODIN II ADCCP stations acknowledge receipt of error-free command frames without waiting for a stimulus from the transmitting station. At the ADCCP level, the state of the P bit does not have any significance. The F bit in all response frames assumes the state of the P bit in the command frame which provoked the response.

23.8.1 Information (I) Frame Acknowledgment. Acknowledgment of I frames is accomplished by one of the following methods.

a. Updating the N(R) count in an outgoing I frame. If the station is currently transmitting I frames, the updated N(R) count is inserted in the next outgoing I frame.

b. Generating an S frame which has a supervisory RR or RNR response containing the updated N(R) count in the case where the station has no I frames to transmit.

In either case, the N(R) count acknowledges all I frames having sequence numbers up to and including N(R) - 1.

AUTODIN II ADCCP stations can send a maximum of seven I frames prior to acknowledgment.

23.8.2 Supervisory (S) Frame Acknowledgment. AUTODIN II ADCCP requires that all S command frames be acknowledged by an S response frame. Only one S command may be outstanding at any one time.

23.8.3 Unnumbered (U) Frame Acknowledgment. All U command frames are acknowledged by generating a UA response at the earliest opportunity. Only one U command may be outstanding at any one time.

23.9 TIMEOUT RECOVERY. AUTODIN II ADCCP requires that various response timers be maintained at each transmitting station in order to implement the Timeout Recovery.

23.9.1 Unnumbered Command Timer. This timer is started when a U command is sent. If a valid response is not received prior to expiration of the timer, the command is retransmitted. If the command is sent three times without a response, the next higher level of protocol is notified. The ADCCP level will, however, continue to retransmit the command until told otherwise by the next higher level of protocol.

23.9.2 Supervisory Command Timer. This timer is started when an S command is sent. If a valid response is not received prior to timer expiration, the command is retransmitted If the command is sent three times without a response, the next higher level of protocol is notified. The ADCCP level will, however, continue to retransmit the command until told otherwise by the next higher level of protocol.

23.9.3 Information Frame Timer. This timer is started on the occurrence of one of the following conditions:

a. There are no more I frames to send

b. The maximum number of unacknowledged I frames have been sent

If the timer expires and the I frames are still outstanding (unacknowledged), the appropriate S command frame is sent to solicit an acknowledgement and the S timer is started. If the RR or RNR command is transmitted three times without a response, the next higher level of protocol is notified of this condition. The ADCCP level then continues to send the RR or RNR command until instructed otherwise by the higher level of protocol.

If a response to the S command frame is received prior to S timer expiration, its N(R) will satisfy one of three cases:

a. N(R) acknowledges all outstanding I frames
b. N(R) acknowledges a subset of the outstanding I frames
c. N(R) is unbelievable, ie, out of range

In the first case, the error recovery is successful and complete. The outstanding I frames are no longer candidates for retransmission and are purged. Any pending I frames are assigned sequence numbers starting with the value of N(R) and scheduled for transmission.

In the second case, the error recovery is partial. The acknowledged I frames are purged and the remaining outstanding I frames are scheduled for retransmission. In addition, pending I frames may also be scheduled for transmission at this time, provided that the maximum outstanding frame count is not exceeded.

In the third case, it is assumed that the remote station has lost synchronization. A RSET command is sent and the U timer is started. If a UA response is received prior to U timer expiration, the outstanding I frames are assigned new sequence numbers starting with zero and normal I frame transmission resumes. If the RSET command is sent three times without receiving a response, the next higher level of protocol is notified that the RSET has failed. The ADCCP level then sends an SABM command and starts the U timer. If the SABM is sent three times without receiving a response, the next higher level of protocol is notified that the SABM has failed. The ADCCP level continues sending SABM commands until instructed otherwise by the next higher level of protocol. If a response is received prior to the third U timer expiration, the higher level of protocol is notified, the outstanding I frames are assigned new sequence numbers starting with zero, and normal I frame transmission resumes.

23.10 EXCEPTION CONDITION AND ERROR RECOVERY

23.10.1 Busy Condition. A busy condition occurs when a station temporarily cannot receive or continue to receive I frames due to internal constraints, eg, receive buffer limitations. The busy condition is reported by transmission of an S frame containing an RNR response with the N(R) of the next I frame that is expected.

Upon receipt of an RNR response, the transmitting station will generate either an RR or RNR command. The transmitting station will continue sending the RR or RNR command until the busy condition clears (an RR response is received).

23.10.2 Frame Check Sequence (FCS) Error. All frames which contain FCS errors are discarded by the receiving station and no further processing occurs.

23.10.3 Frame Sequence Number Errors. I frames having sequence number errors, ie, N(S) is not equal to the R variable of the receiving station, will be discarded after the N(R) value is extracted from the frame. Since the I frame does not have an FCS error, the N(R) information is assumed to be valid.

23.10.4 Invalid N(R) Error. An invalid N(R) is defined as a number which points to an I frame which has previously been transmitted and acknowledged, or to an I frame which has not been transmitted and is not the next sequential I frame pending transmission.

Receipt of a frame containing an invalid N(R) implies that synchronization has been lost, ie, the send sequence number variable N(S) at the local station does not match the receive sequence number variable N(R) at the remote station. When an AUTODIN II ADCCP station receives a frame containing an invalid N(R) value, it will send a RSET command to the remote station and start the U timer. If the RSET command is acknowledged prior to U timer expiration, any outstanding I frames are assigned new sequence numbers starting with zero and normal I frame transmission resumes. If the RSET is sent three times without receiving a response, the next higher level of protocol is notified and the ADCCP level sends an SABM command. If the SABM command is sent three times and no acknowledgment is received, the next higher level of protocol is notified. The ADCCP level continues sending the SABM until told otherwise. If a response to the SABM is received prior to the third timeout, the higher level of protocol is notified, any outstanding I frames are assigned new sequence numbers starting with zero, and normal I frame transmission resumes.

23.10.5 Mode-Setting Contention. A mode-setting contention situation exists when a station issues a mode-setting command, SABM, and receives a mode-setting command from the remote station prior to receiving the proper response to the issued command. In the AUTODIN II system, this contention is resolved when each station sends a UA response and enters the indicated mode.

23.10.6 Abort. Abort is the procedure by which a station in the process of sending a frame, ends the frame in an unusual manner such that the receiving station will ignore the frame. Aborting a frame is performed by transmitting at least 7, but less than 15, contiguous one bits (with no inserted zeros).

23.10.7 Invalid Frame. An invalid frame is defined as one that is not properly bounded by two flag sequences (thus an aborted frame is an invalid frame) or one which is too short, eg, shorter than 32 bits between flags).

23.10.8 Frame Reject Conditions. AUTODIN II ADCCP stations initiate a FRMR response upon receipt of an error-free frame (FCS is valid) containing the following:

a. An invalid command or response.

b. An I field which exceeds the maximum length.

c. An invalid frame format, eg, a frame which does not conform to the structure implied by the command/response contained in its control field.

AUTODIN II ADCCP stations will generate a U frame containing an FRMR response whose status field will indicate the reason why the receiver rejected the frame.

23.11 TIMING AND SYNCHRONIZATION

23.11.1 Idle Link Periods. AUTODIN II ADCCP stations will provide for continuous flag sequences to be exchanged during idle link periods to maintain synchronization on the circuit and for the periodic interjection of supervisory commands. These supervisory commands will consist of either Receiver Ready (RR) or Receiver Not Ready (RNR). The frequency of these interjected RR and RNR commands will be controlled by an inactive link timer maintained by the transmitting station. The timer is reset when the local station transmits any traffic.

23.11.2 Inactive Link Timer. AUTODIN II ADCCP stations maintain a timer which monitors link activity. If the local station is inactive, ie, sending flag sequences only during the interval of the timer, a Supervisory command will be sent upon timer expiration and the timer will be restarted.

23.12 NETWORK CONTROL MESSAGES. The system design uses the ADCCP unnumbered format to allow the exchange of short supervisory frames. Unnumbered (U) format commands and responses are used to extend the number of link supervisory functions. Frames transmitted in the unnumbered format do not increment the send sequence numbers.

23.13 MODE VI DATA FORMATS. Figure B-2 shows the Mode VI link protocols that will be used in AUTODIN II. Information (I), Supervisory (S) and Unnumbered (U) frames are illustrated in this figure with sequence numbers, commands, and responses in the control field. The following items are illustrated in this figure:

a. Initialization and one way operation of I Frames
b. Supervisory Commands and Responses
c. Unnumbered Information (UI) Commands
d. Operation of Poll/Final (P/F) Bit in Control Field
e. Abort Sequence
f. Zero Bit Insertion
g. Frame Reject
h. Frame Timer Timeouts
i. Error Recovery of Information (I) Frames
j. Mode - Setting Contention
k. Frame Sequence Number Errors
l. Two Way Simultaneous Operation

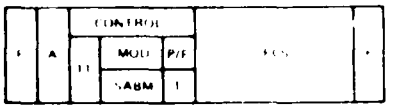
The input data from Mode VI terminals to the TAC operate in accordance with THP command procedures described in Section 27. The Mode VI host/channel control unit to the SCM has a binary segment leader (BSL) in accordance with the segment interface protocol (SIP) specification. The THP command data from terminals or the binary segment leader from a CCU is in the information field of the Mode VI frame format.

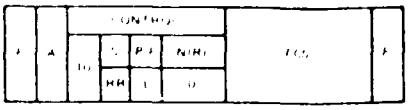
ABBREVIATIONS APPLICABLE TO FIGURE B-2

1. F - Flag Sequence 01111110
2. A - Address File
3. Control Field
   - 0 - Information Frame (I)
   - 10 - Supervisory Frame (S)
   - 11 - Unnumbered Frame (U)
   - P - Poll Bit
   - F - Final Bit
   - MOD - Unnumbered Command or Response
   - N(S) - Send Sequence Number (0 through 7)
   - N(R) - Receive Sequence Number (0 through 7) which indicates the sequence number of the next expected I Frame
   - S - Supervisory Command/Response
4. FCS - Frame Check Sequence
5. INFO - Information Field. This field size is variable and ranges from 0 to a maximum of 5072 bits on access lines
6. SABM - Set Asynchronous Balanced Mode (Command)
7. UA - Unnumbered Acknowledgment (Response)
8. RR - Receiver Ready (Command/Response)
9. RNR - Receiver Not Ready (Command/Response)
10. UI - Unnumbered Information (Command/Response)
11. RSET - Reset (Command)
12. FRMR - Frame Reject Response (Response)

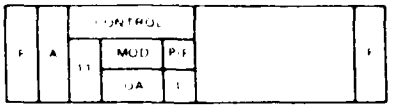
A ONE I FRAME

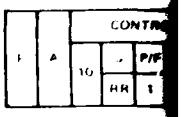
COMMAND





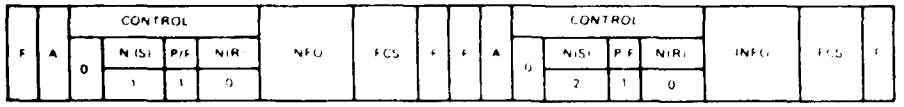
RESPONSE



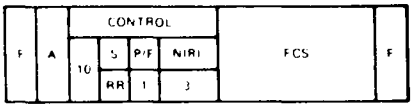


B TWO I FRAMES

COMMAND

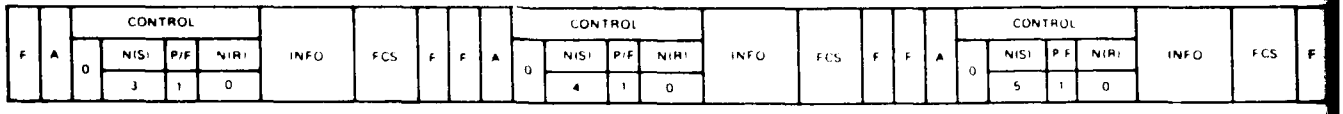


RESPONSE



C THREE I FRAMES

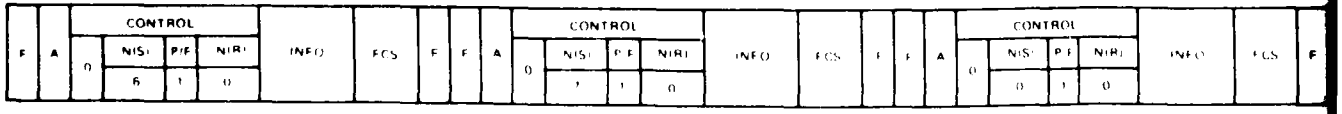
COMMAND



RESPONSE

D FOUR I FRAMES

COMMAND



RESPONSE

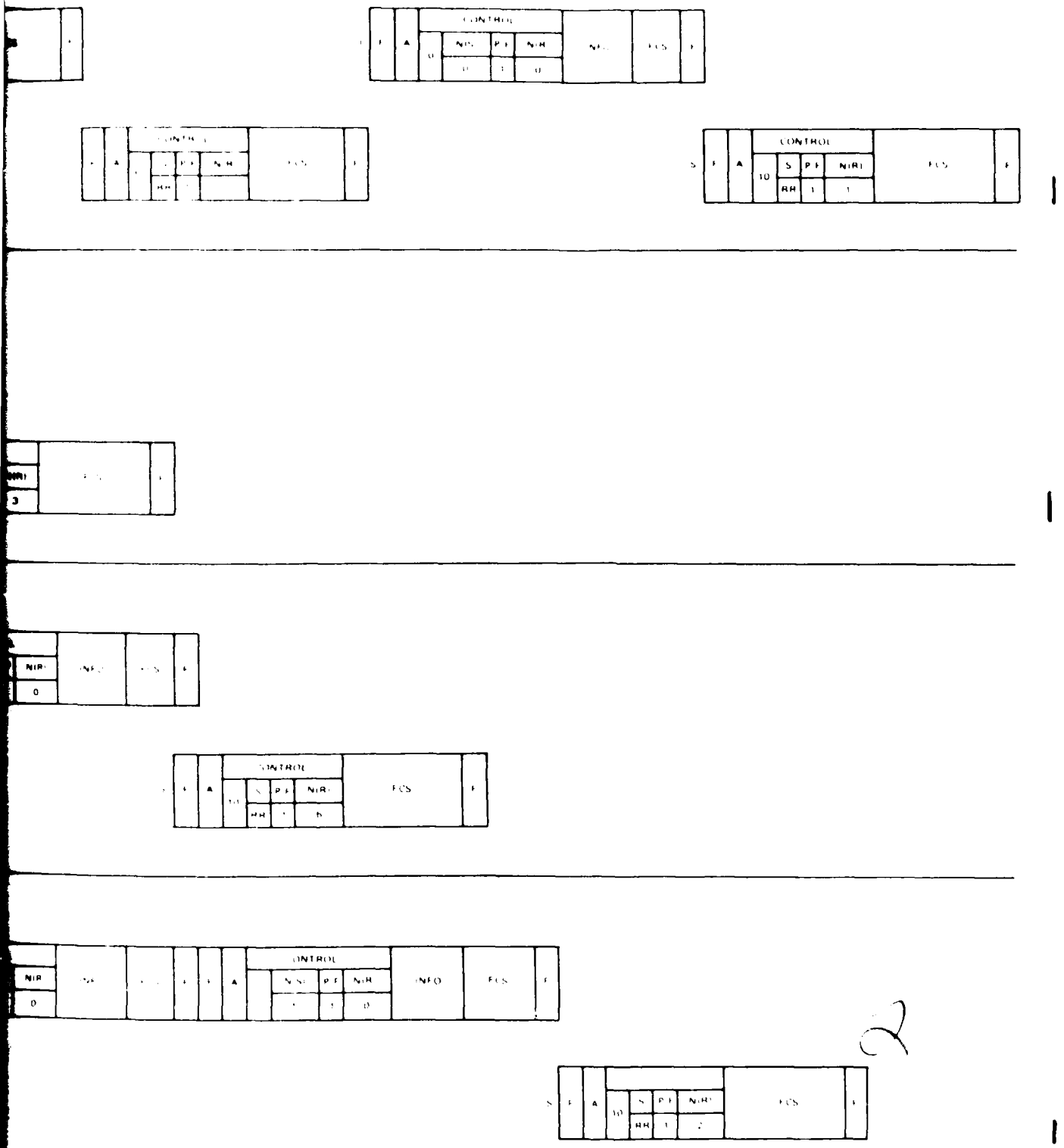
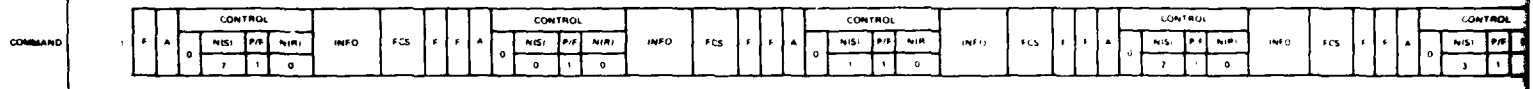


Figure B-2. Mode VI Link Protocol
(Sheet 1 of 17)

1 ONE WAY OPERATION (CONT'D)

E FIVE I FRAMES

F SIX I FRAMES



G SEVEN I FRAMES

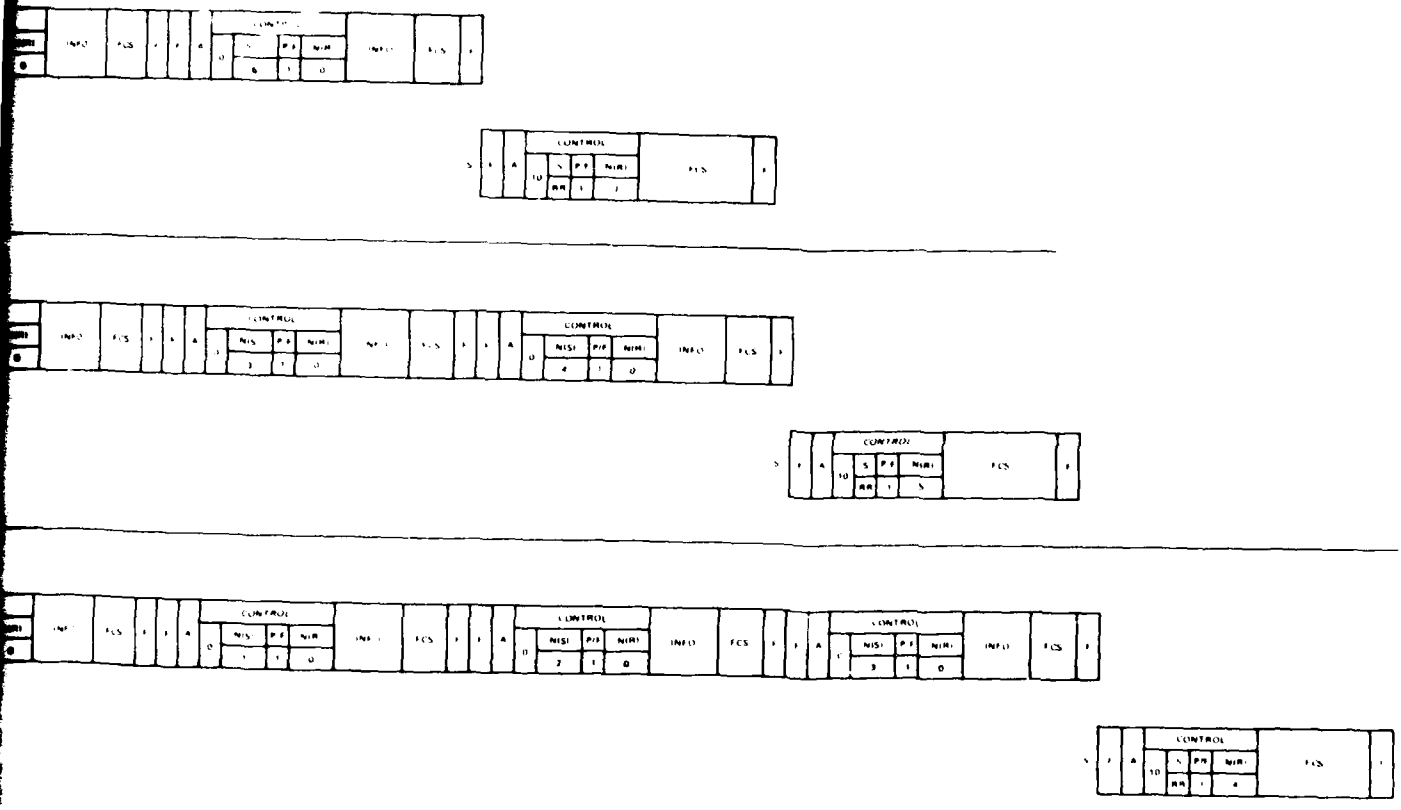


Figure B-2. Mode VI Link Protocol
(Sheet 2 of 17)

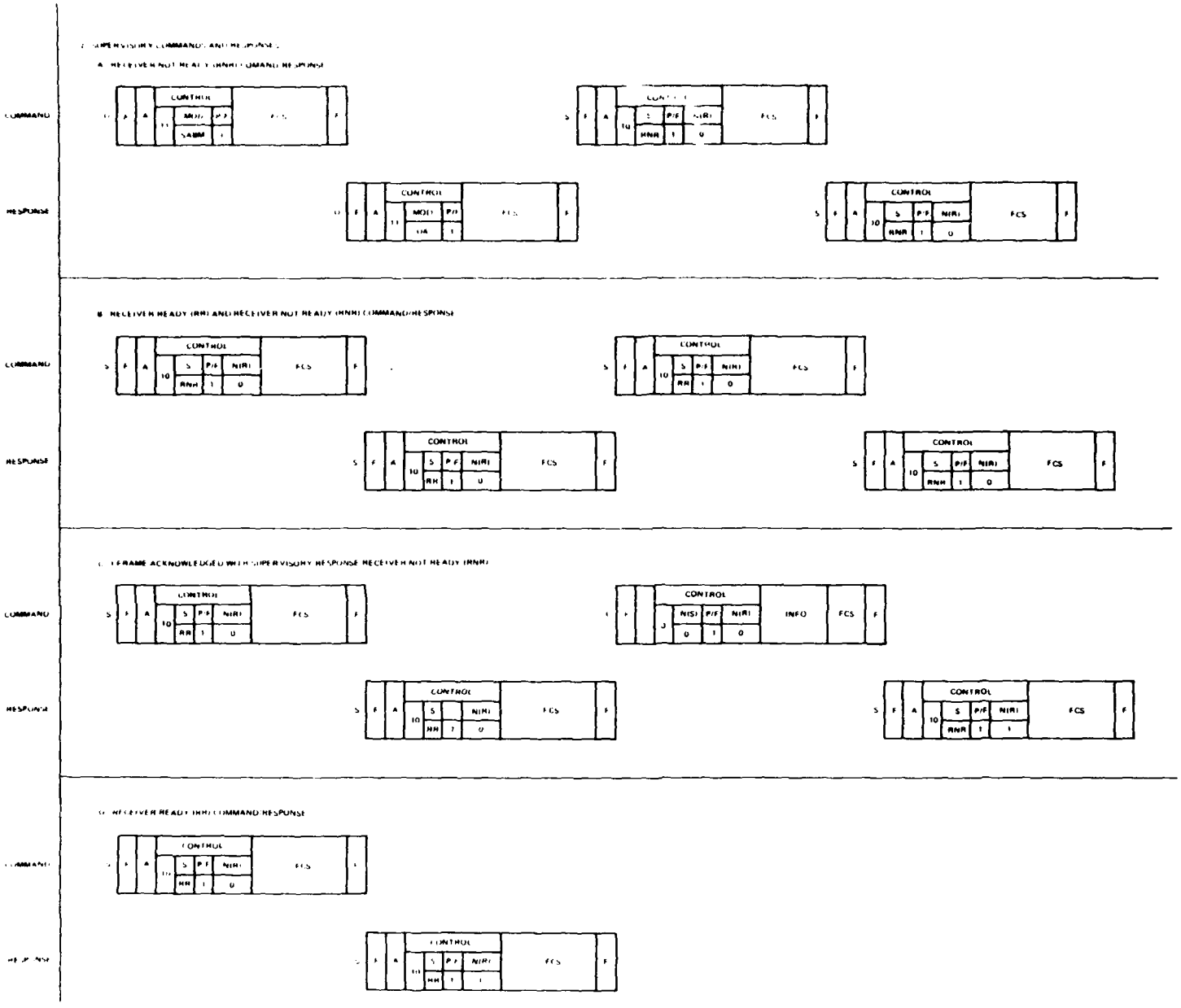


Figure B-2. Mode VI Link Protocol (Sheet 3 of 17)

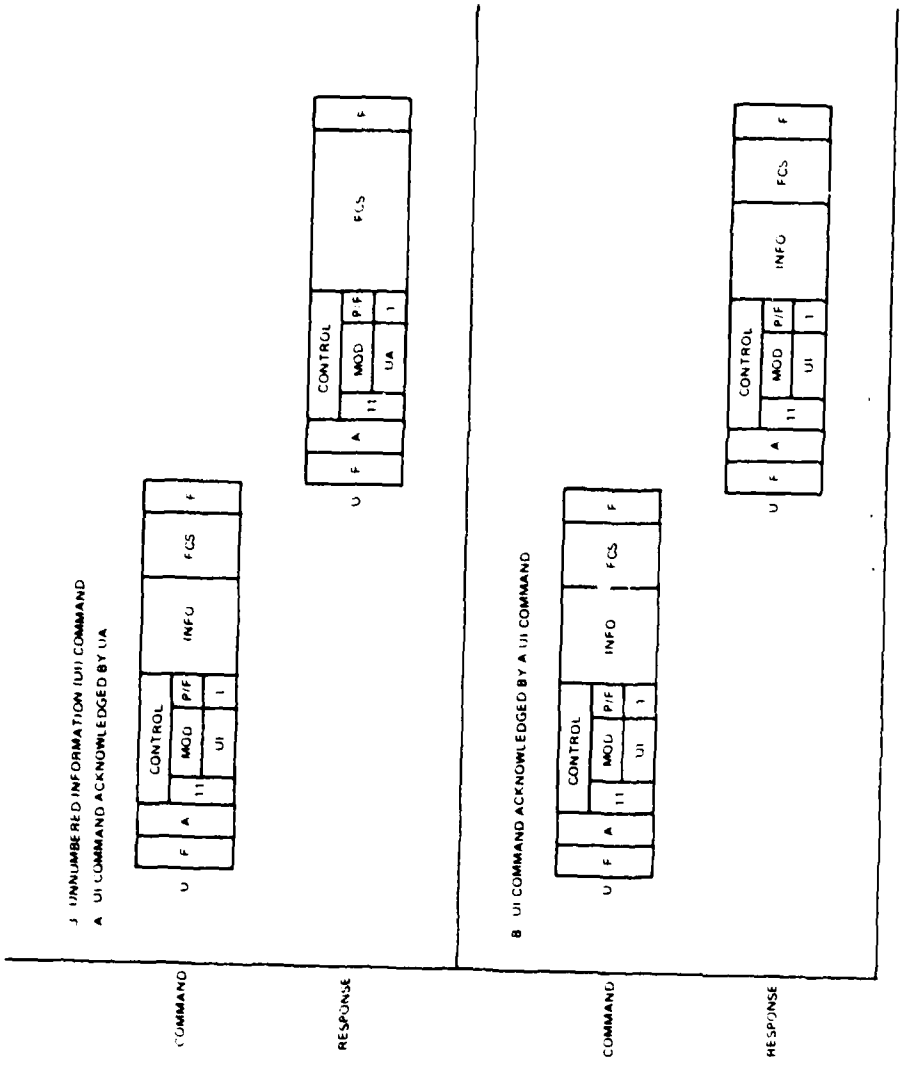


Figure B-2. Mode VI Link Protocol (Sheet 4 of 17)

4 POLL/FINAL (P/F) BIT IN CONTROL FIELD

A SUPERVISORY COMMAND WITH P/F BIT SET TO A 1 IN THE CONTROL FIELD

COMMAND

S	F	A	CONTROL				FCS	F
			10	S	P/F	N(R)		
				RR	1	0		

RESPONSE

S	F	A	CONTROL				FCS	F
			10	S	P/F	N(R)		
				RR	1	1		

NOTE AT THE ADCCP LEVEL THE STATE OF THE P BIT DOES NOT HAVE ANY SIGNIFICANCE THE F BIT IN ALL RESPONSE FRAMES ASSUMES THE STATE OF THE P BITS IN THE COMMAND FRAME WHICH PROVOKED THE RESPONSE

B INFORMATION FRAME WITH P/F BIT SET TO A 1 IN THE CONTROL FIELD

COMMAND

I	F	A	CONTROL				INFO	FCS	F
			0	N(S)	P/F	N(R)			
				1	1	0			

RESPONSE

S	F	A	CONTROL				FCS	F
			10	S	P/F	N(R)		
				RR	1	2		

C UNNUMBERED FRAME WITH P/F BIT SET TO A 1 IN THE CONTROL FIELD

COMMAND

U	F	A	CONTROL			INFO	FCS	F
			11	MOD	P/F			
				UI	1			

RESPONSE

U	F	A	CONTROL			INFO	FCS	F
			11	MOD	P/F			
				UI	1			

NOTE IF A UI COMMAND WITH THE P BIT SET IS RECEIVED IT INDICATES TO THE RECEIVER THAT A UI RESPONSE IS REQUIRED

Figure B-2. Mode VI Link Protocol (Sheet 5 of 17)

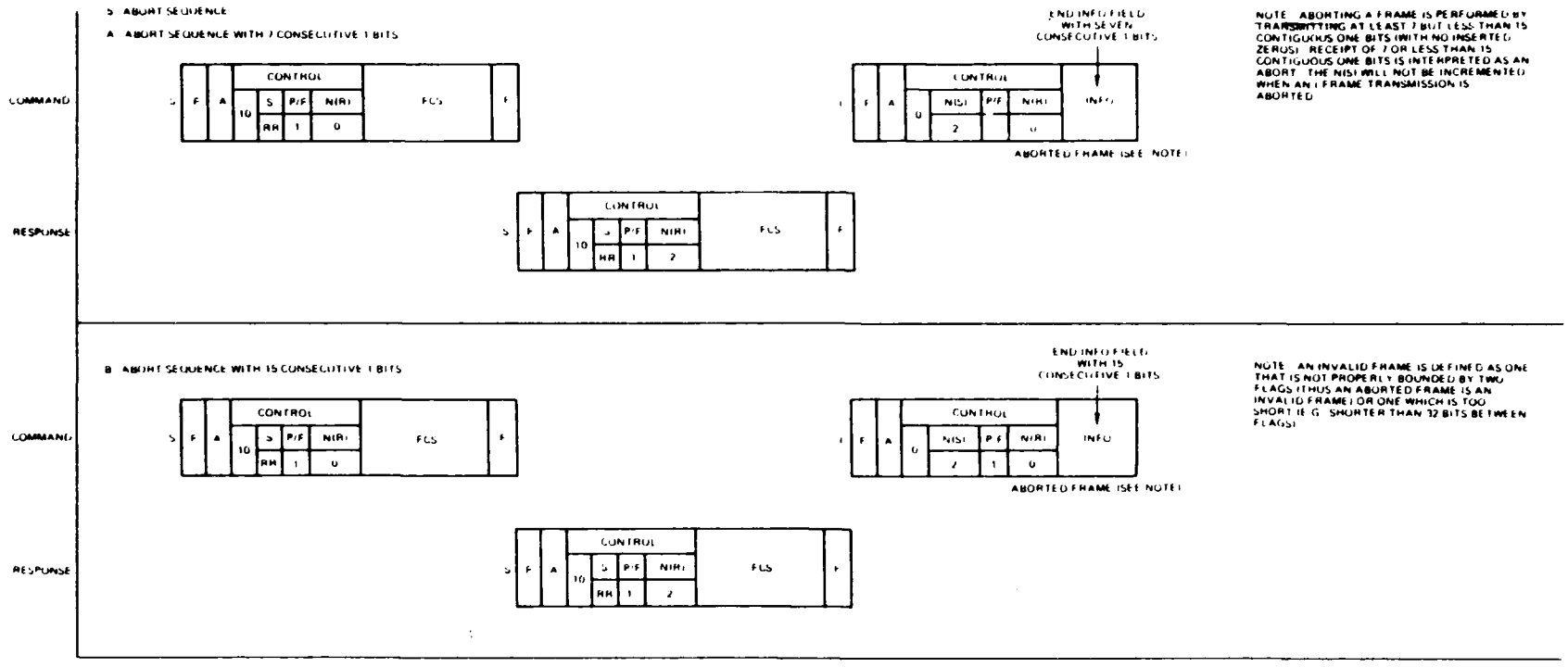
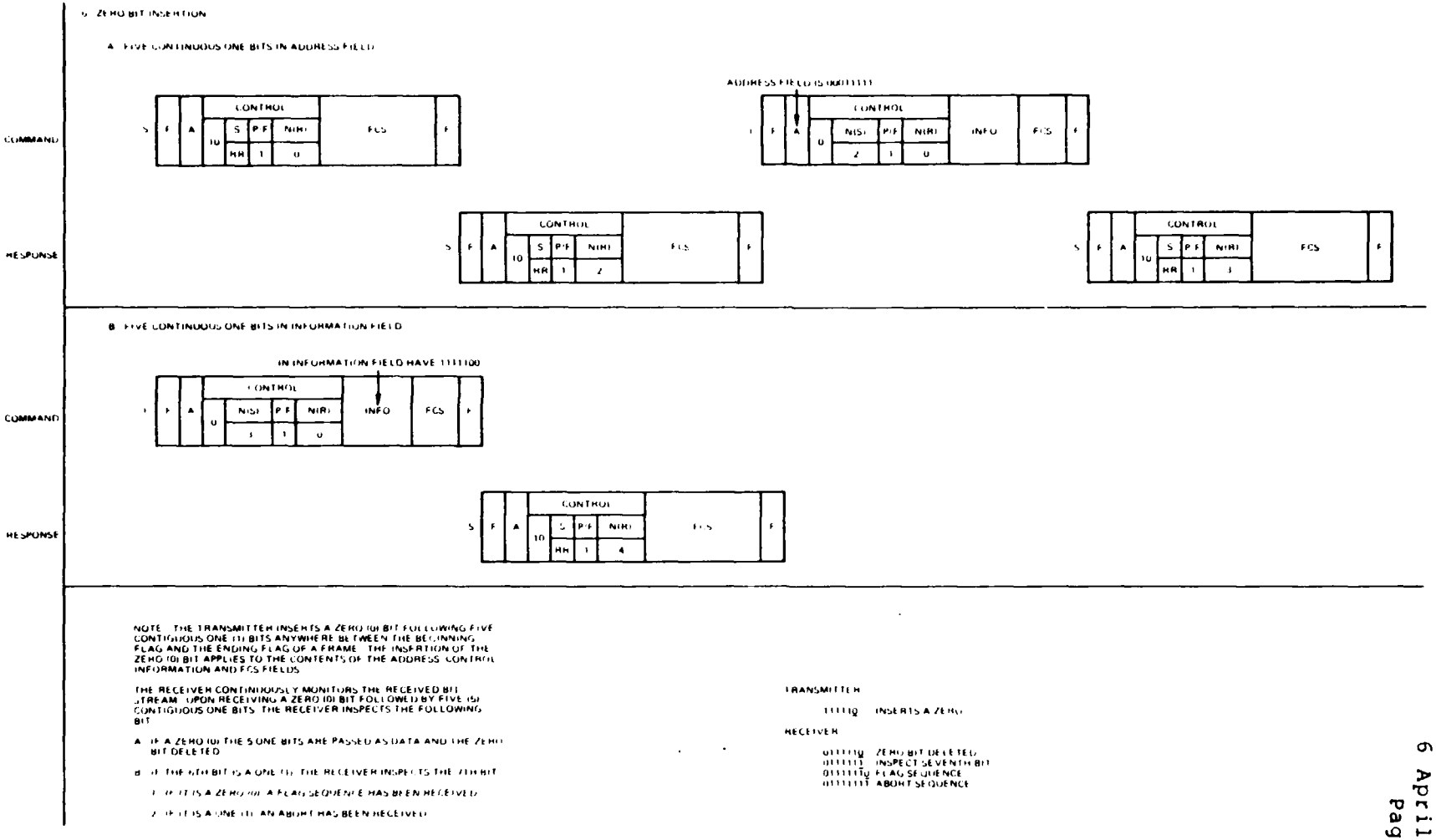


Figure B-2. Mode VI Link Protocol (Sheet 6 of 17)



NOTE: THE TRANSMITTER INSERTS A ZERO (0) BIT FOLLOWING FIVE CONTIGUOUS ONE (1) BITS ANYWHERE BETWEEN THE BEGINNING FLAG AND THE ENDING FLAG OF A FRAME. THE INSERTION OF THE ZERO (0) BIT APPLIES TO THE CONTENTS OF THE ADDRESS, CONTROL INFORMATION AND FCS FIELDS.

THE RECEIVER CONTINUOUSLY MONITORS THE RECEIVED BIT STREAM. UPON RECEIVING A ZERO (0) BIT FOLLOWED BY FIVE (5) CONTIGUOUS ONE BITS, THE RECEIVER INSPECTS THE FOLLOWING BIT.

A. IF A ZERO (0), THE 5 ONE BITS ARE PASSED AS DATA AND THE ZERO BIT DELETED.

B. IF THE 6TH BIT IS A ONE (1), THE RECEIVER INSPECTS THE 7TH BIT.

1. IF IT IS A ZERO (0), A FLAG SEQUENCE HAS BEEN RECEIVED.

2. IF IT IS A ONE (1), AN ABORT HAS BEEN RECEIVED.

TRANSMITTER

111110 INSERTS A ZERO

RECEIVER

0111110 ZERO BIT DELETED
0111111 INSPECT SEVENTH BIT
01111110 FLAG SEQUENCE
01111111 ABORT SEQUENCE

Figure B-2. Mode VI Link Protocol (Sheet 7 of 17)

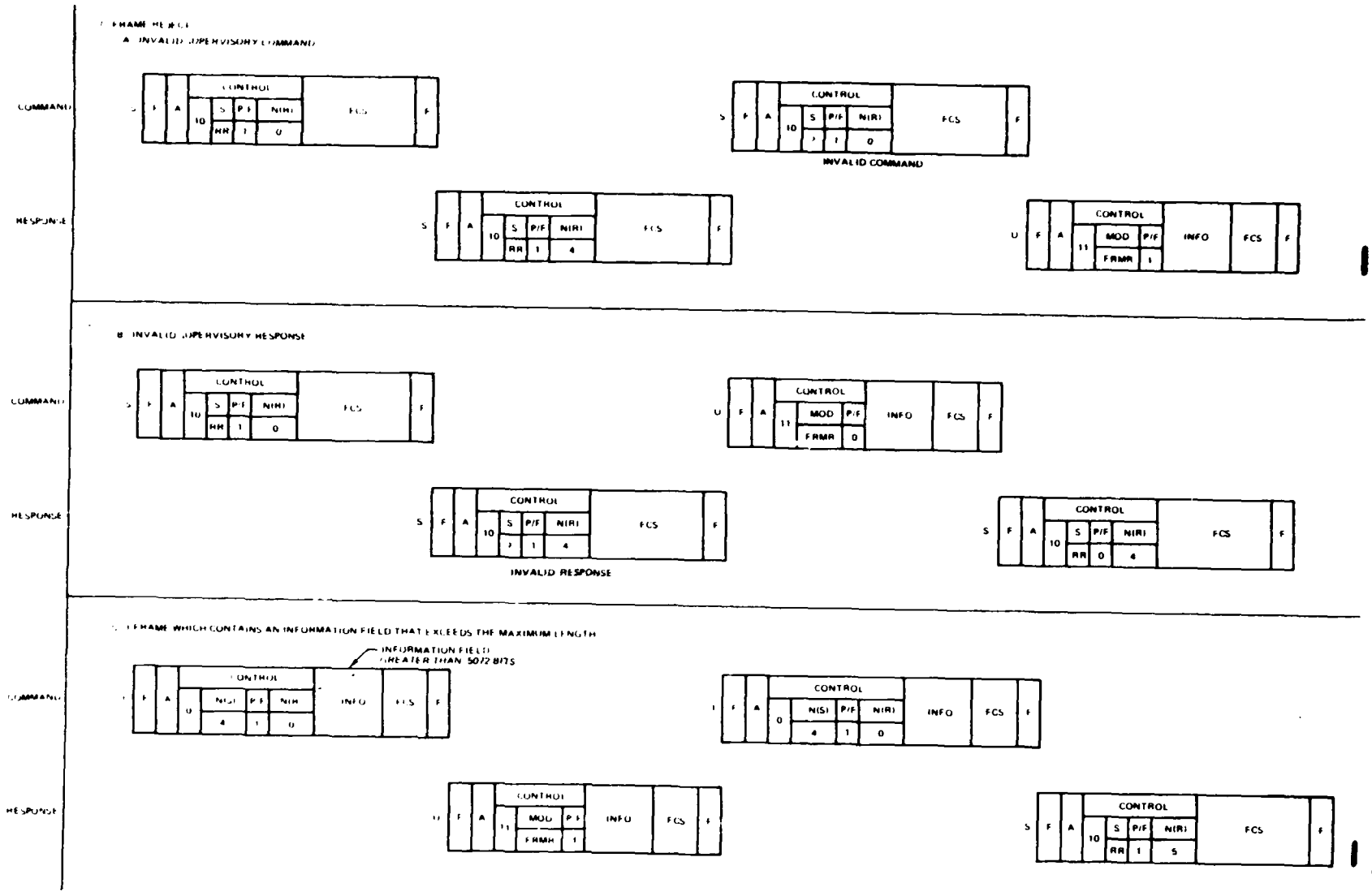


Figure B-2. Mode VI Link Protocol (Sheet 8 of 17)

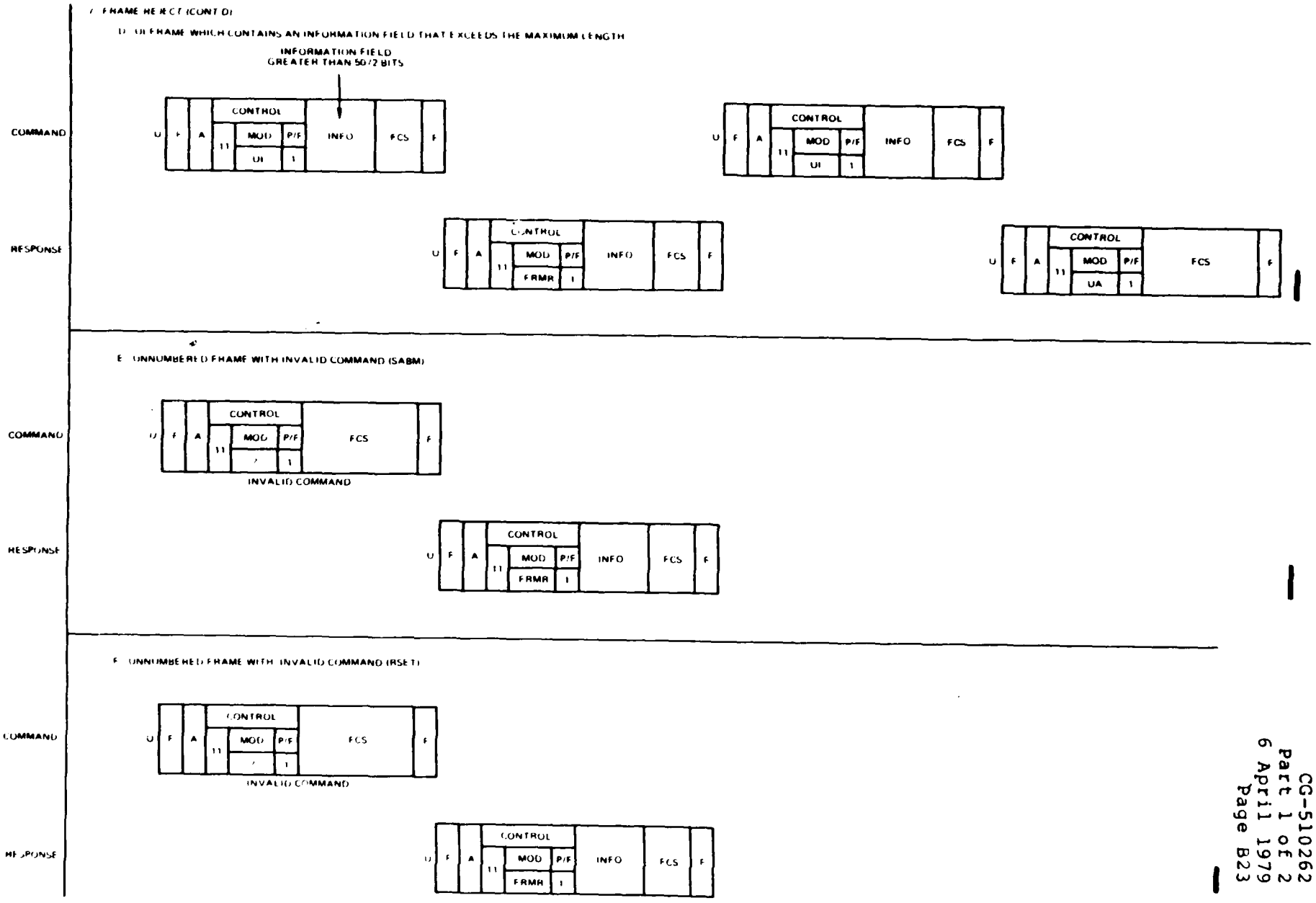


Figure B-2. Mode VI Link Protocol (Sheet 9 of 17)

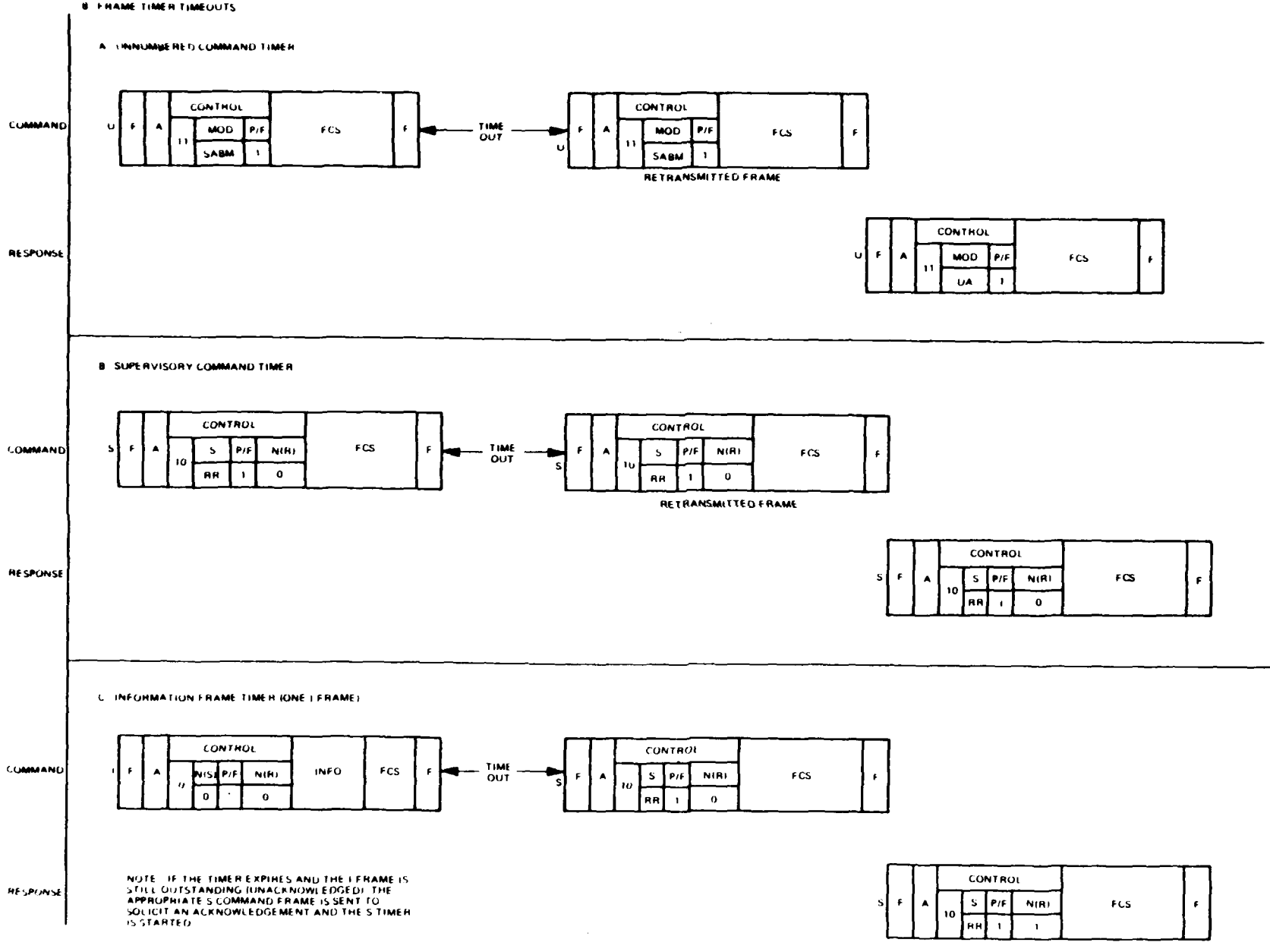


Figure B-2. Mode VI Link Protocol (Sheet 10 of 17)

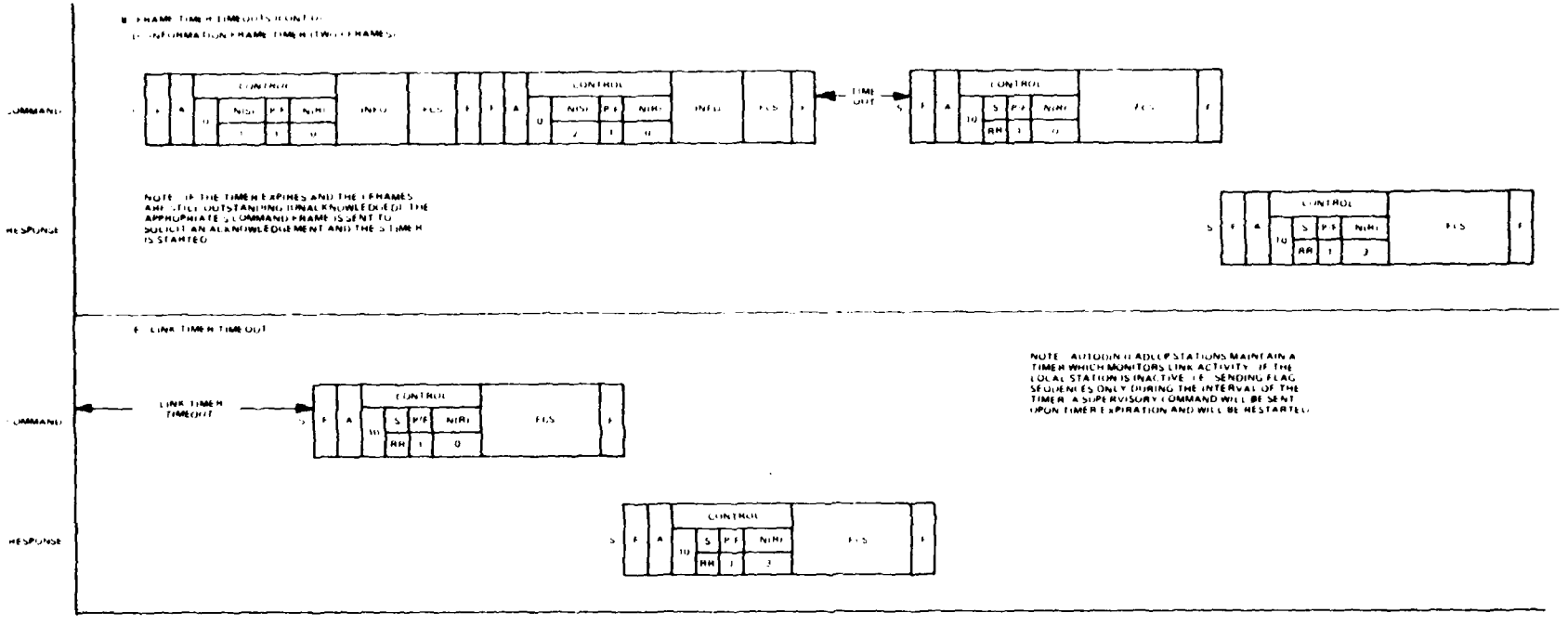
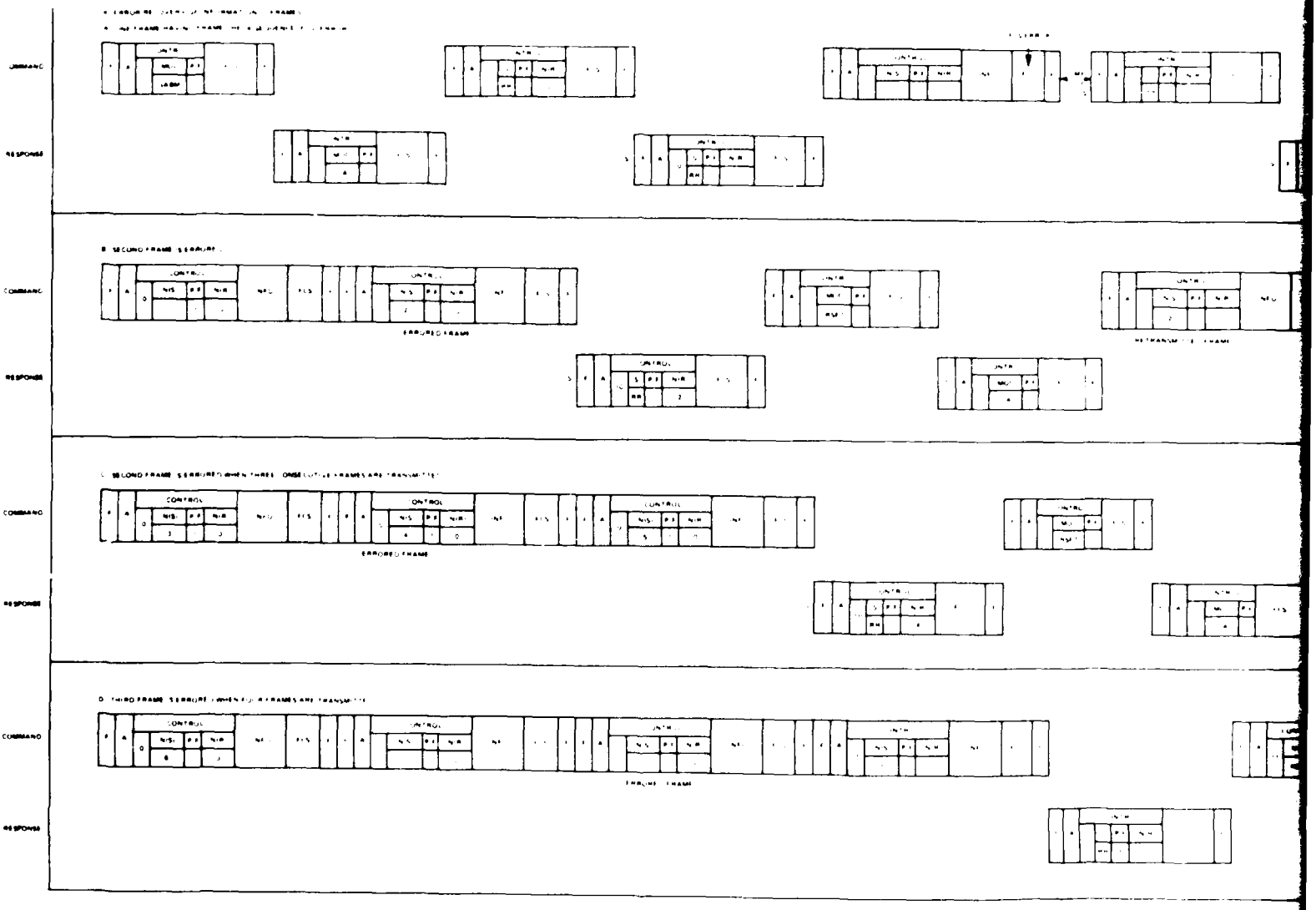


Figure B-2. Mode VI Link Protocol (Sheet 11 of 17)


COMMAND
RESPONSE
B. SECOND FRAME ERROR
ERRORED FRAME
RETRANSMITTED FRAME
C. SECOND FRAME ERROR WHEN THREE CONSECUTIVE FRAMES ARE TRANSMITTED
ERRORED FRAME
D. THIRD FRAME ERROR WHEN FOUR FRAMES ARE TRANSMITTED
ERRORED FRAME

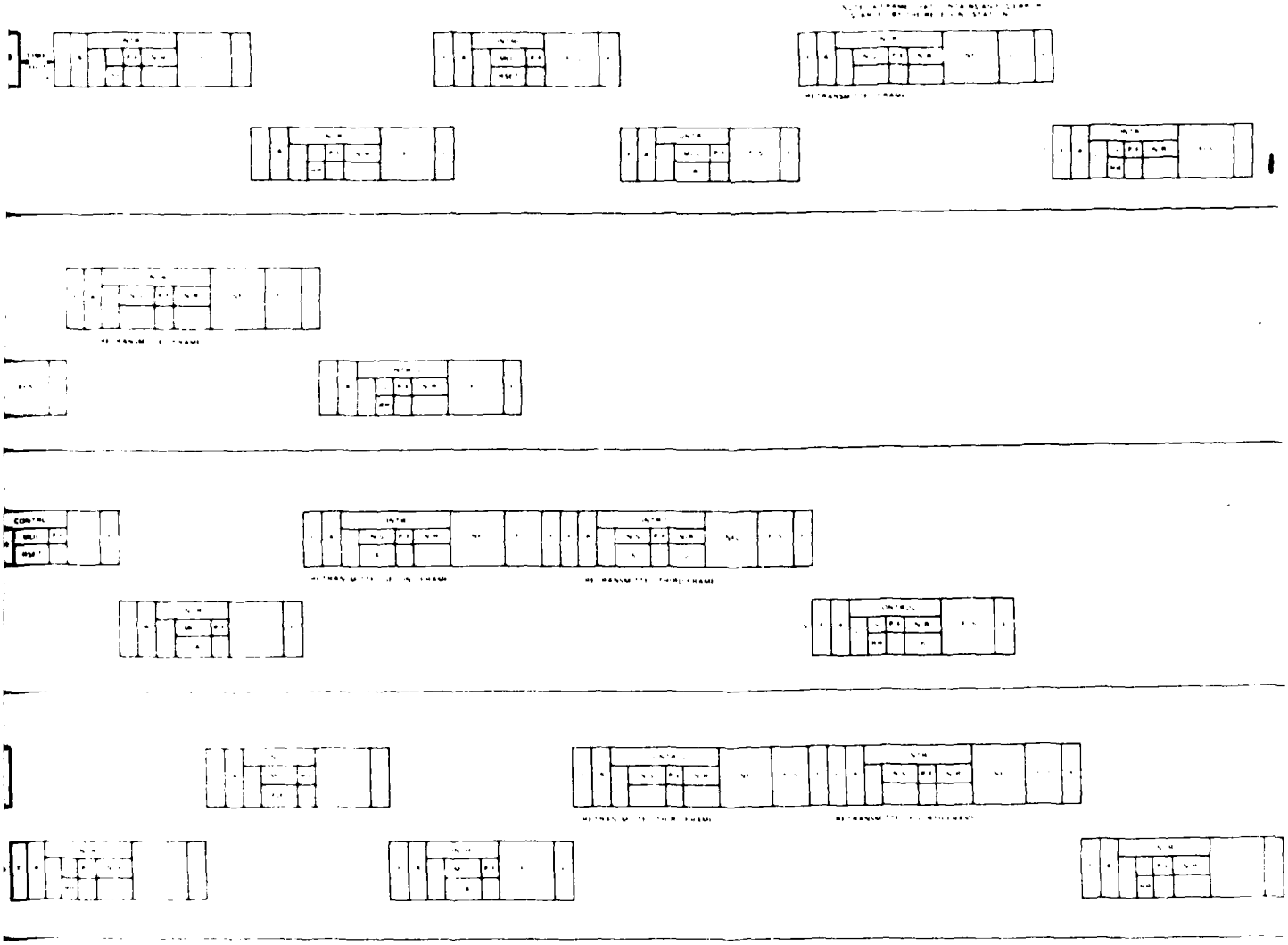


Figure B-2. Mode VI Link Protocol
(Sheet 12 of 17)

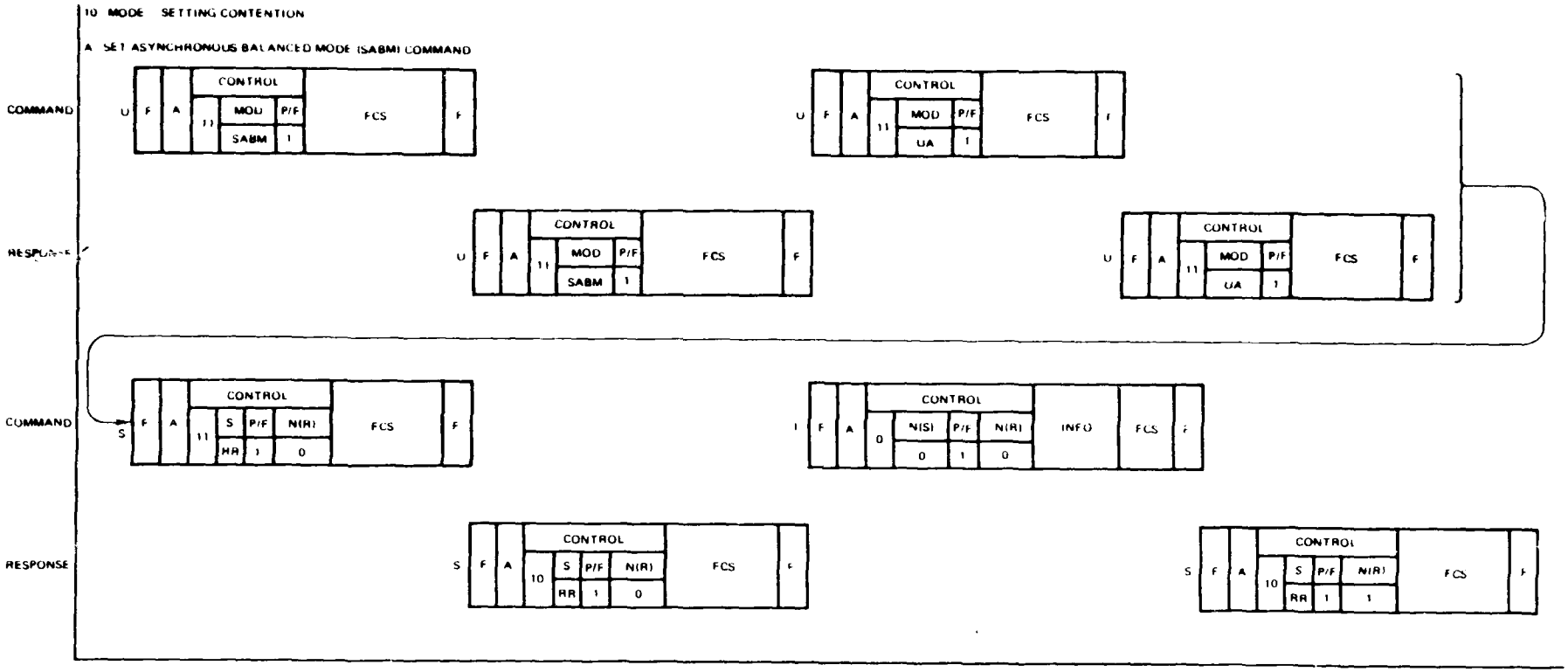


Figure B-2. Mode VI Link Protocol (Sheet 13 of 17)

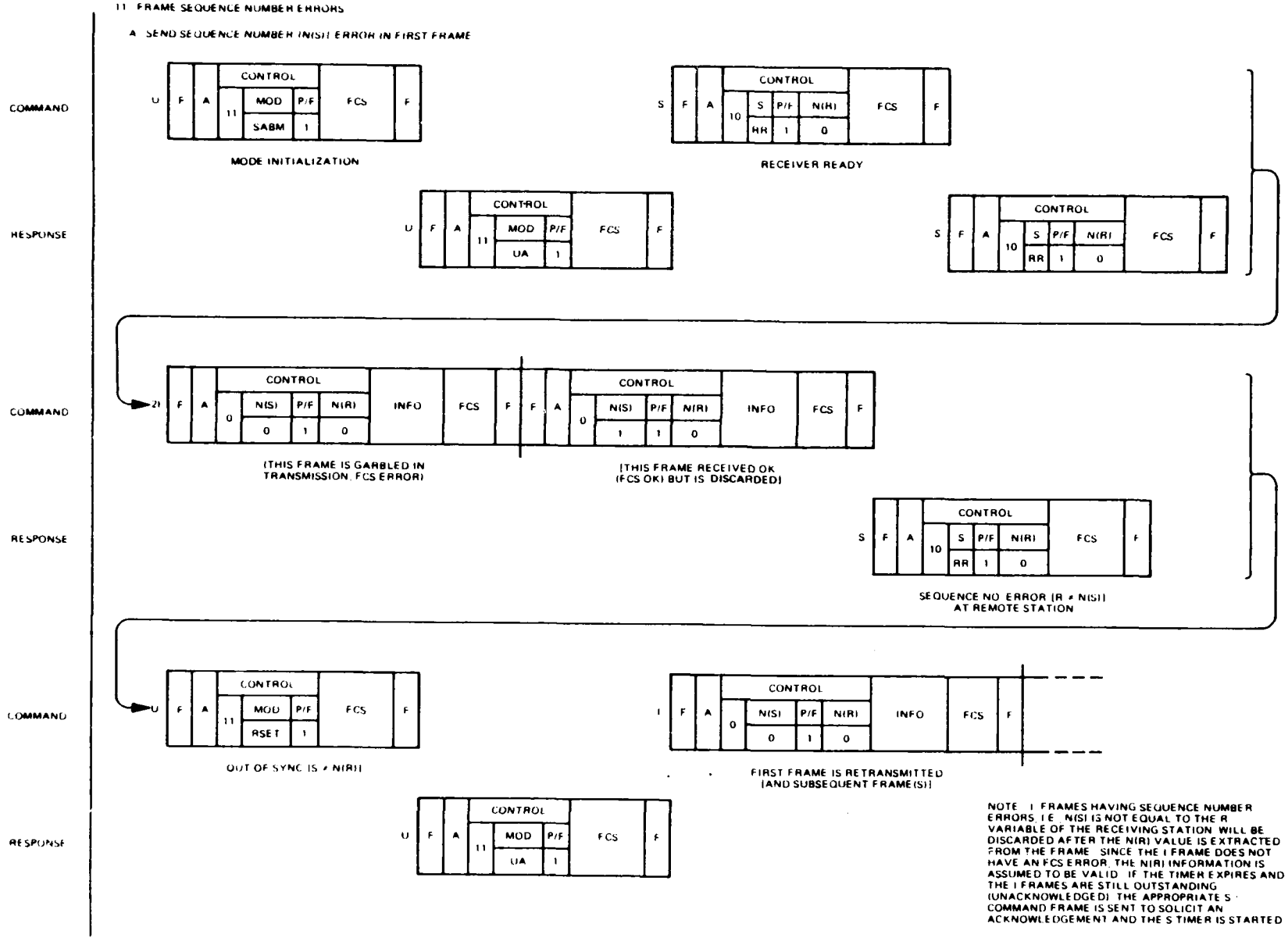


Figure B-2. Mode VI Link Protocol (Sheet 14 of 17)

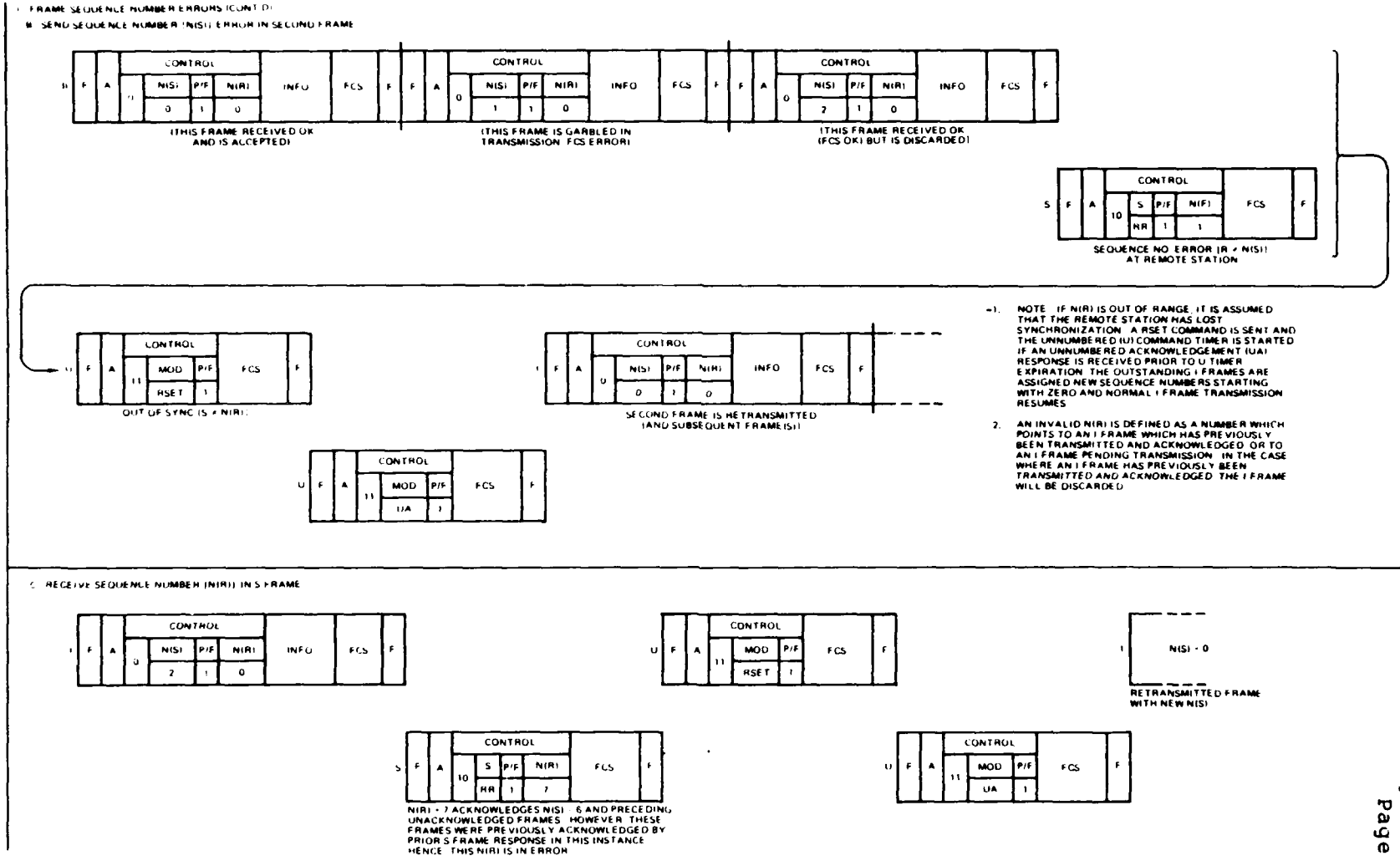
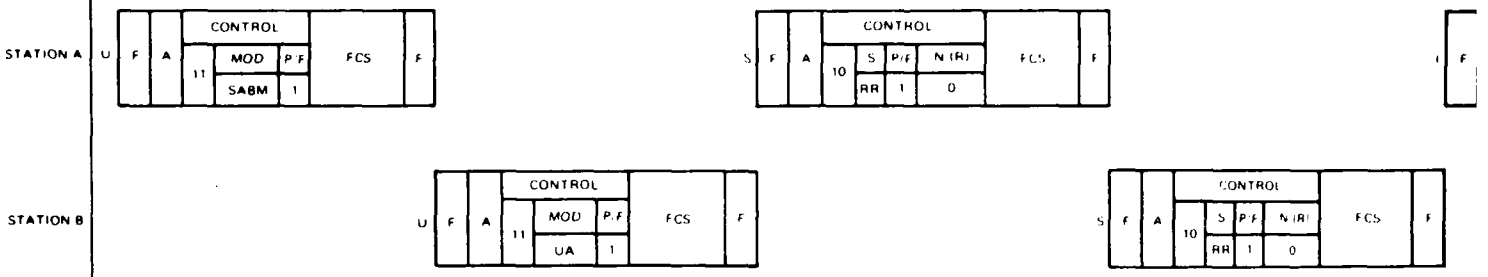


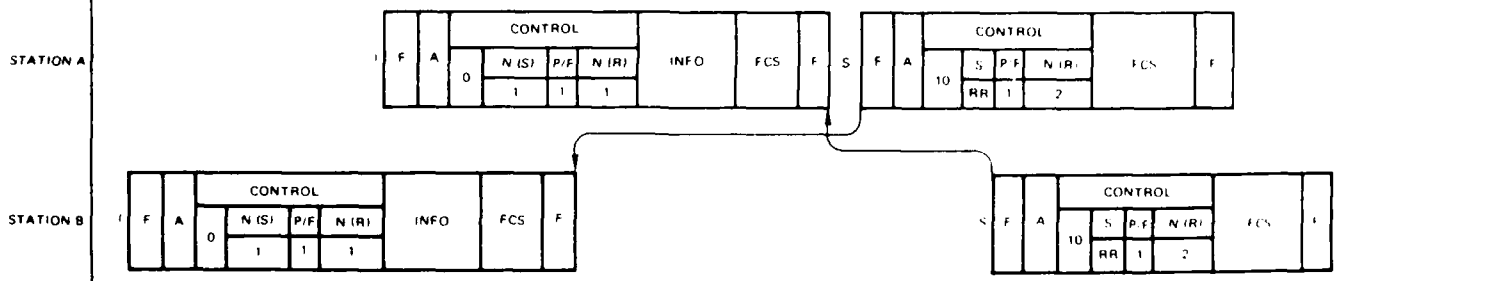
Figure B-2. Mode VI Link Protocol (Sheet 15 of 17)

12 TWO WAY SIMULTANEOUS OPERATION

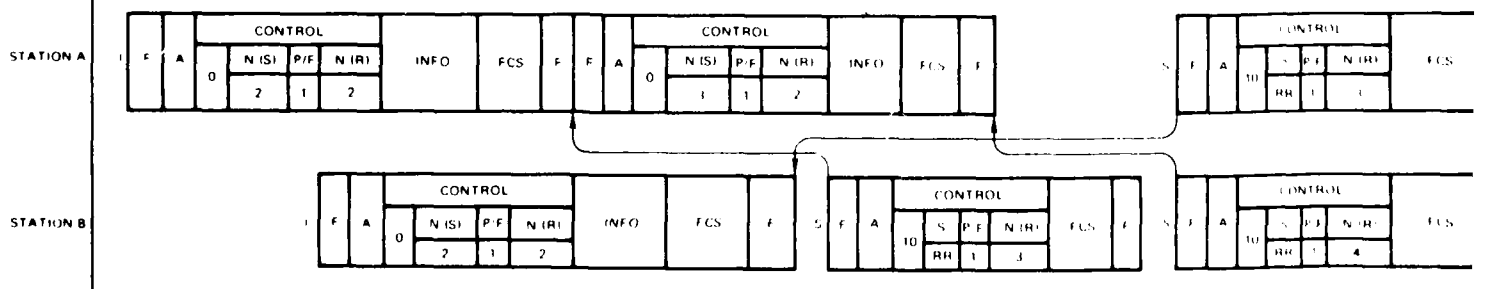
A ONE FRAME ACKNOWLEDGED BY ANOTHER FRAME

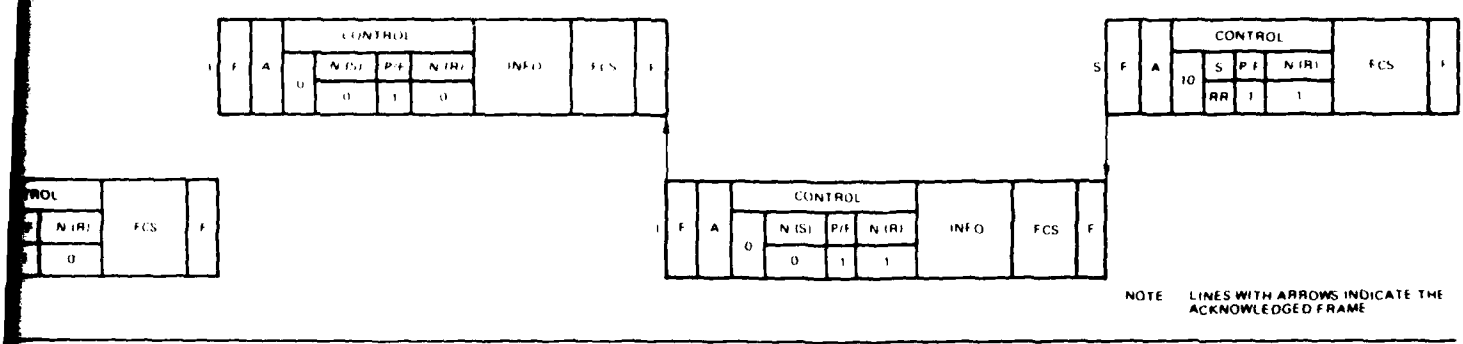


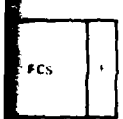
B ONE FRAME ACKNOWLEDGED BY AN S COMMAND

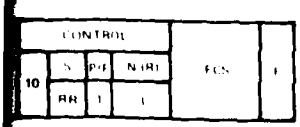


C TWO FRAMES ACKNOWLEDGED BY S COMMANDS









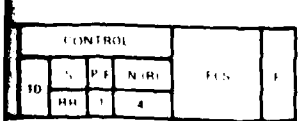
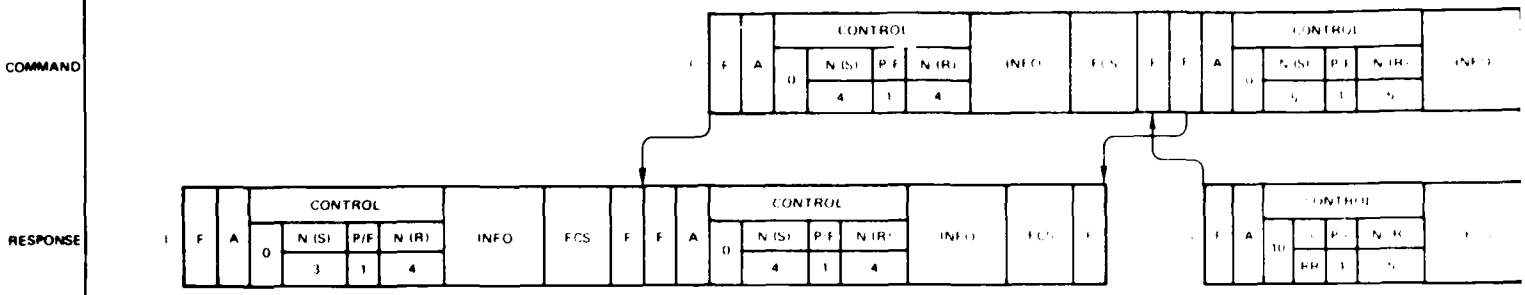


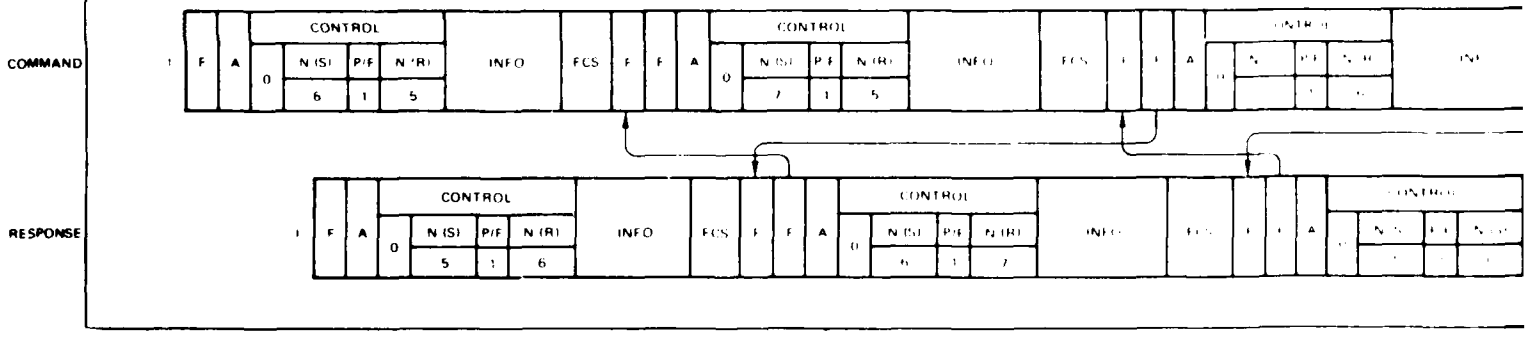
Figure B-2. Mode VI Link Protocol
(Sheet 16 of 17)

12 TWO WAY SIMULTANEOUS OPERATION (CONT)

D TWO I FRAMES ACKNOWLEDGED BY I AND S FRAMES



E THREE I FRAMES ACKNOWLEDGED BY I AND S FRAMES



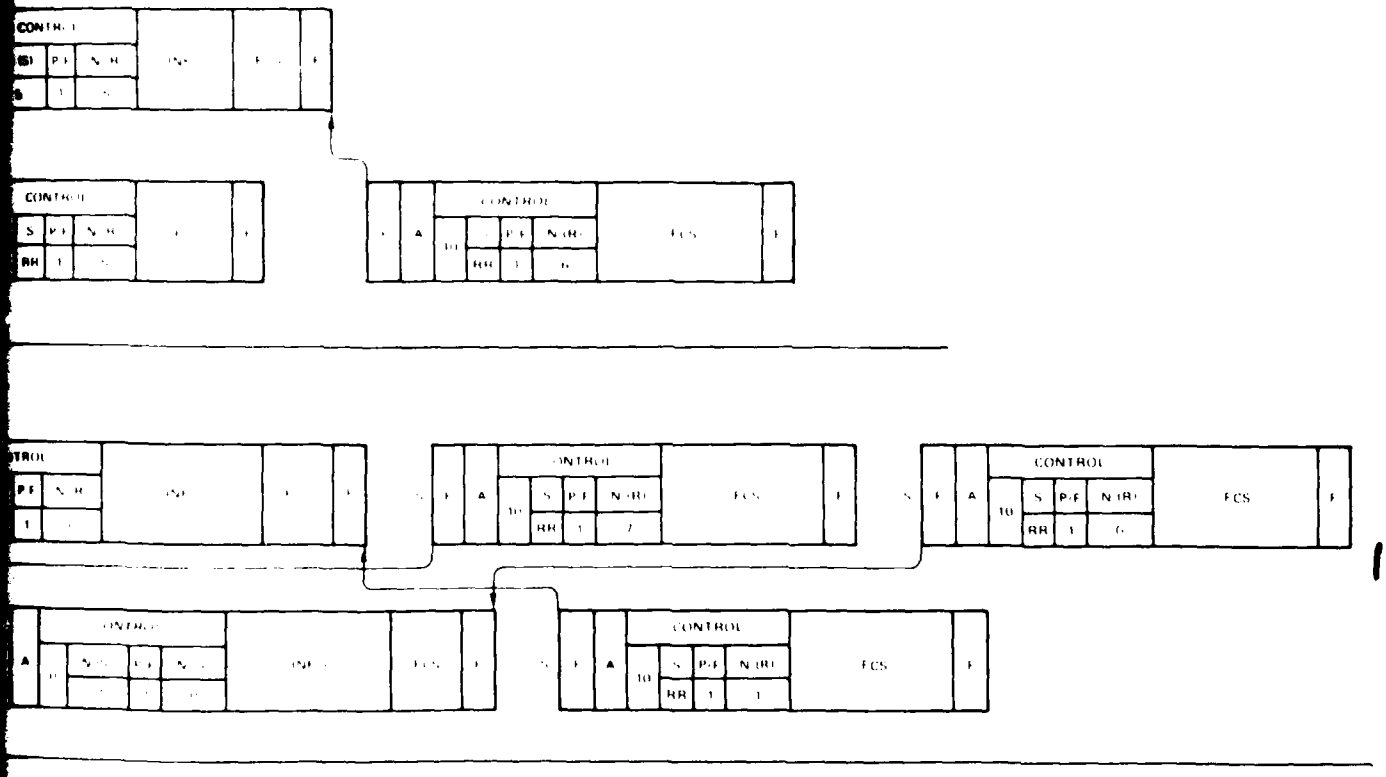


Figure B-2. Mode VI Link Protocol
(Sheet 17 of 17)

SECTION 24 - MODE I LINK PROTOCOL

24.1 INTRODUCTION. Mode I link protocol is employed in access protocols that facilitate communication between certain (Character) terminal subscribers and AUTODIN II. Mode I is a full-duplex character-oriented synchronous type of link control. It uses character parity and block parity checking along with retransmission of errored blocks to achieve an automatic error detection and correction capability. Mode I allows independent, simultaneous operation between both ends of a link. The AUTODIN II Packet Switch Network will interoperate with subscribers and other networks according to the Mode I continuous mode requirements defined in paragraph 24.2 below.

24.2 APPLICABLE DOCUMENT

DCAC 370 - D175-1	DCS AUTODIN Interface and Control Criteria dated 2 October 1970, Chapters 1, 3, 4, and 5.

24.3 MODE I CHARACTERISTICS. The following summarizes the salient features of the Mode I link protocol to be implemented in the AUTODIN II network:

a. Full Duplex (FDX) operation

b. Synchronous operation

c. Coordinated continuous transmission through the use of control characters

d. Character parity and block parity (BP)

e. Transmission code (7-bit ASCII)

f. Character-oriented (7-bits information plus 1-bit parity)

   1. Control character - even parity

   2. Data character - odd parity

g. Block parity character odd or even (ie, no specific parity on this character since it is the result of computation of longitudinal parity)

h. Each block may contain 80 text characters and four framing characters for a maximum of 84 characters

i. Two framing characters precede the block and two succeed the block

j. A block is permitted to be less than 80 characters provided the last character is followed by the special control character "End of Medium" (EM)

k. Characters are transmitted serially by bit, with the low order first and the parity bit last

l. The last character in every block is the BP, which is Modulo-2 addition of all the characters in the block starting with the second framing character

m. Insert two-character control sequences into outgoing data stream without interfering with data sequence.

24.4 FRAMING CHARACTERS. The framing characters and control characters delineate the beginning and end of each serial block. Two of these control characters precede the block and two succeed the block. There are seven control characters that have fixed bit structures; namely SOH (Start of Heading), SEL (Select), STX (Start of Text), DEL (Delete), ETB (End of Transmission Block), ETX (End of Text) and EM (End of Medium) which are even parity characters. The DEL Character has a fixed bit structure, although it is not a control character in the strictest sense. The SEL could take any of the 12 values defined in Table B-I. The block parity is a result of Modulo-2 computation; hence, its bit structure will vary depending on the block it represents. Its parity could be odd or even, depending on the parity vector in that block. The bit structure for control characters used in Mode I operation is defined in Tables B-II and B-III for a seven-bit American Standard Code for Information Interchange (ASCII).

Refer to the Mode I data format in paragraph 24.11.

Table B-I. SEL Characters

Select Characters	Identification
A	Teletypewriter format and code
B	Identifier source transmission tape 7-track
C	Identifier source transmission tape 9-track
D	Card format
F	Switch card flash messages identification Active operator alarm
G	Identifies the block transmitted in response to ENQ
H	ASCII paper tape
J	Message switching unit - MSU CONUS AUTODIN
K	Circuit switching unit - CSU CONUS AUTODIN
M	Reserved for future use
P	Reserved for future use
S	Switch paper tape flashing messages identification -- Active operator alarm

Table B-II. American Standard Code for Information Exchange (ASCII)

Bits b_7 b_6 b_5	$0\ 0\ 0$	$0\ 0\ 1$	$0\ 1\ 0$	$0\ 1\ 1$	$1\ 0\ 0$	$1\ 0\ 1$	$1\ 1\ 0$	$1\ 1\ 1$
b_4 b_3 b_2 b_1 COLUMN / ROW	0	1	2	3	4	5	6	7
0 0 0 0 0	NUL	DLE	SP	0	@	P	`	p
0 0 0 1 1	SOH	DC1	!	1	A	Q	a	q
0 0 1 0 2	STX	DC2	"	2	B	R	b	r
0 0 1 1 3	ETX	DC3	#	3	C	S	c	s
0 1 0 0 4	EOT	DC4	$	4	D	T	d	t
0 1 0 1 5	ENQ	NAK	%	5	E	U	e	u
0 1 1 0 6	ACK	SYN	&	6	F	V	f	v
0 1 1 1 7	BEL	ETB	'	7	G	W	g	w
1 0 0 0 8	BS	CAN	(	8	H	X	h	x
1 0 0 1 9	HT	EM	)	9	I	Y	i	y
1 0 1 0 10	LF	SUB	*	:	J	Z	j	z
1 0 1 1 11	VT	ESC	+	;	K	[	k	{
1 1 0 0 12	FF	FS	,	<	L	\	l	|
1 1 0 1 13	CR	GS	-	=	M	]	m	}
1 1 1 0 14	SO	RS	.	>	N	^	n	~
1 1 1 1 15	SI	US	/	?	O	_	o	DEL

Table B-III. DCS AUTODIN Control Code for ASCII

b7					0	0	0	0	1	1	1	1
b6					0	0	1	1	0	0	1	1
b5					0	1	0	1	0	1	0	1
b4	b3	b2	b1*	COLUMN / ROW	0	1	2	3	4	5	6	7
0	0	0	0	0						P		
0	0	0	1	1	SOH	REP**			A			
0	0	1	0	2	STX	RM**			B	R		
0	0	1	1	3	ETX				C	S		
0	1	0	0	4		STOP**			D	T		
0	1	0	1	5	ENQ**	NAK**			E	U		
0	1	1	0	6	ACK 1**	SYN			F			
0	1	1	1	7	INV**	ETB			G			
1	0	0	0	8		CAN**			H			
1	0	0	1	9		EM						
1	0	1	0	10		MC			J			
1	0	1	1	11					K			
1	1	0	0	12		ACK 2**						
1	1	0	1	13		START**			M			
1	1	1	0	14		WBT**						
1	1	1	1	15								DEL

* b_1 is the low order bit

** These control characters are transmitted in identical continuous pairs.

24.4.1 Start of Heading (SOH). SOH is the first framing character of the first block of a message. It is an even-parity character, and is always followed by the select character.

24.4.2 Select (SEL). SEL is the second framing character of the first block of a message. It is an alphabetic character with even parity. Refer to Table B-I. Select characters that may be used at the transmitting subscriber terminal are A, B, C, D, J, K, M, P, G, and H. At the transmitting subscriber terminal, the select character is determined on the basis of the switch setting. At the receiving end, the messages are routed to the output device associated with the select character, with the exception of a narrative message containing either S or F select characters. The S or F select characters will be sent to the specified output device, depending upon subscriber terminal configuration. Select characters that may be used by the Terminal Access Controller (TAC) are A, B, C, D, F, M, P, S, and H. The bit structure of these codes is shown in Table B-II.

24.4.3 Start of Text (STX). STX is the first framing character of all blocks except the first block of a message. STX is an even parity character.

24.4.4 Delete (DEL). DEL is the second framing character position of all blocks, with the exception of the first block of a message. Its presence indicates that the subscriber is a terminal; thus, a terminal inserts DEL in this position when sending data to TAC, and TAC inserts DEL when transmitting data to a terminal. DEL is an even parity character.

24.4.5 End of Transmission Block (ETB). ETB is the third framing character of all blocks except the last block. ETB always appears in the 83rd character position of a block or following EM in those messages where the block is short (ie, less than 84 characters). ETB is an even parity character.

24.4.6 End of Text (ETX). ETX is the third framing character of the last block of a message. It is an even parity character. ETX always appears in the 83rd character position of the last block or following EM in those messages where the last block is short.

24.4.7 End of Medium (EM). EM is a special control character which marks the end of text in a block containing 79 characters or less. Like the other control characters, it will have even parity and it will be included in the block parity check. EM will be followed by ETB-BP or ETX-BP in the case of the last block.

24.4.8 Block Parity (BP). BP is the last framing character of every block in the message. BP always follows ETB or ETX. Contrary to the other framing characters that use even parity, BP may be either odd or even parity resulting from Modulo-2 addition without carry of all the bits in each row vector of a block, starting with the second framing character, including all the text, the EM (if used), and ETX or ETB. At the receiving end,

the received BP character is compared bit for bit with the receiver-generated BP character. The two characters must be identical. If not, the block is considered to be in error.

It should be noted that the response characters (receive control characters) are not included in the block parity. The generation of the BP character at both ends and the correlation process at the receiving end are done by software in the Line Control Module (LCM).

24.5 RECEIVE CONTROL CHARACTERS. The receive control characters are answers or responses to the transmitted blocks which are sent by a receiving station when requested (through transmit control characters) to do so by the transmitting station. These characters are ACK1 (Acknowledgment No. 1), ACK2 (Acknowledgment No. 2), NAK (Negative Acknowledge), RM (Reject Your Message) and WBT (Wait Before Transmitting). The receive control characters are transmitted in pairs which are inserted anywhere in the bit stream except between two adjacent framing characters. They are not added to the block parity sum nor are they counted in establishing the position of ETB or ETX. Refer to the Mode I data formats in 24.10. Requests for answers are as follows:

a. ETB-BP or ETX-BP if the rest of the block is in proper format with the proper framing character

b. Transmit control character REP (Reply) sequence

c. Transmit Control Character CAN (Cancel) sequence

d. Transmit Control Character ENQ (Enquiry) sequence

When a request for an answer is received, the receiving station will respond with an answer which is inserted in the transmitter side.

24.5.1 Acknowledge No. 1 - ACK1. ACK1 is sent by a receiving station to signal the transmitting station that the first block has been received correctly. Subsequently, ACK1 is used alternately with ACK2 to indicate correctly received blocks.

24.5.2 Acknowledge No. 2 - ACK2. ACK2 is sent by a receiving station to signal the transmitting station of every correct block received after the block which was answered with ACK1. The sequence of alternating ACK1 and ACK2 is not interrupted between messages; ie, if the answer to the last block of a message was ACK1, the answer to the first block of the following message will be ACK2. ACK2 is the proper answer to the transmit control character CAN sequence.

24.5.3 Negative Acknowledge - NAK. NAK is sent by the receiving station when an error is detected during the receipt of a block. It is sent when the answer is requested (ETB/BP, ETX/BP, REP, CAN) and not at the time of detecting the error. Upon receipt of NAK, the transmitter will repeat the complete block for which the NAK applies.

24.5.4 Reject Your Message - RM. RM is sent by the receiving station to inform the transmitter that there is a defect in the message that cannot be corrected by retransmission of the block. Upon receipt of RM, the transmitter will cause the message to be cancelled. Subscriber terminals are permitted to send an RM only on a power-up condition, a loss of power, or a return from self-test. Computer interface subscribers are permitted to send RM only after receipt of the BP character.

24.5.5 Wait Before Transmitting - WBT. WBT is sent by the receiving station (in response to receiving a good block) to inform the transmitter that it can no longer accept blocks. While WBT is being received, the transmitting station can send only control characters or SYNC characters.

24.6 TRANSMIT CONTROL CHARACTERS. Transmit control characters are sent by the transmitting station to direct the receiving station to take some action. These characters, REP (REPLY), CAN (CANCEL), and ENQ (ENQUIRY), are transmitted in identical continuous pairs. Each character is even parity. They may be transmitted only between blocks or following the 82nd character in continuous mode. Refer to Mode I data formats in 24.11.

24.6.1 Reply - REP. REP is sent by the transmitting station to direct the receiver to send its last response or its current updated response; ie, ACK1, ACK2, NAK, RM, or WBT. Each transmitting station will have a variable timer that will be started when the BP character is transmitted. When the timer expires, REP is transmitted if any of the following occurs:

a. ACK1, ACK2, NAK, or RM has not been received.
b. WBT has been received.
c. No answer has been received.

The timer will be restarted each time REP is sent, and stopped when ACK1, ACK2, NAK, or RM is received. If REP is sent three times without a reply from the receiver, an alarm will be activated.

The precise timer settings will depend upon such parameters as transmission speed, length of the line, and delays in the modems. For continuous mode operation this timer setting may expire within the block following the one for which the answer is outstanding. In this case, the first REP should not be sent until the 80 data characters or EM for this block has been sent.

24.6.2 Cancel - CAN. CAN is sent by a transmitting station to direct the receiver to cancel or discard the message currently being received. Between messages it serves as a means of synchronizing the ACK sequence. CAN is initiated by the receipt of RM as the response to a block and acknowledged with receive control character ACK2.

CAN is never transmitted within the text portion of a block nor when the answer to a block is outstanding. If the response to a block is WBT, CAN must not be sent until ACK1, ACK2, NAK or RM has been substituted for WBT by the receiver. CAN must be acknowledged with ACK2. When CAN is sent, the answer timer will be started and if ACK2 has not been received when the timer expires, CAN will be retransmitted. If the response to CAN is WBT, CAN will continue to be sent each time the timer expires. If CAN is sent three times without a reply from the receiver, an alarm will be activated and the CAN sequence will continue to be sent at predetermined intervals.

24.6.3 Enquiry - ENQ. ENQ is sent by the TAC to request that an AUTOVON and a common carrier subscriber terminal identity itself. The answer to ENQ will be the terminal identifier sent in a predetermined format.

24.7 SPECIAL CONTROL CHARACTERS. These control characters include EM (End of Medium), INV (Suspected Invalid Message), and MC (Mode Change). Like the other control characters, they will have even parity. EM and MC will be included in the block parity. Refer to the Mode I Data Formats in 24.11.

24.7.1 End of Medium (EM). This special control character is presented in 24.4.7.

24.7.2 Suspected Invalid Message (INV). INV is sent by the TAC or subscriber terminal when an unsolicited answer is received. INV will be transmitted as a dual character sequence in response to each ACK1, ACK2, NAK, RM, or WBT sequence received when an answer is not expected by the transmitter. INV may be interspersed anywhere in the bit stream except between two adjacent framing characters or between adjacent characters of a two character control sequence.

24.8 LINE SYNCHRONIZATION

24.8.1 Synchronous Idle - SYN. SYN is used with synchronous operation to enable character synchronization of the bit stream between the terminal and the LCM. SYN is an even parity character, which is transmitted continuously when no other characters are being exchanged.

24.8.2 Character Frame. When establishing character frame, the receiver will look for the SYN character. Four contiguous SYN characters will be received before the receiver considers itself to be in character frame. The SYN character will have even parity. The receiver will consider itself out of frame when it fails to detect four contiguous SYN characters or a REP or CAN sequence within a time delay equal to the answer timer setting. The time delay will start when the block parity character is received or when the receiver is ignoring characters waiting for a REP or CAN. The time delay will be stopped when the expected SOH or STX character is received. The time delay will be restarted whenever four contiguous SYN characters or a REP or CAN sequence is received.

The PSN access interface will provide channel timing and the two levels of synchronization required for PSN subscribers operating in Mode I. The precise timing required for Mode I channels will be provided by a master station clock. The AUTODIN II Mode I access interface will transmit the special even parity control character SYN on all Mode I circuits when no other characters are being exchanged. From these characters the communication equipment, particularly the crypto equipment, will establish and maintain bit synchronization. After the cryptographic units are bit synchronized, the Line Control Module (LCM) and the Mode I subscriber will establish character frame. The LCM receiver interface will immediately attempt to reestablish character frame when the receiver times out or fails to detect SYN.

24.9 CONTINUOUS OPERATION REQUIREMENTS. Continuous operation is designed for high-reliability circuits over which the percentage of block retransmissions is relatively low. In this operation, transmission of a second block can start prior to receipt of the proper ACK for the first block. The PSN can support continuous mode and block-by-block operations on Mode I circuits. Refer to the Mode I Data Formats in 24.11 for continuous operation.

24.9.1 Transmit Mode. The transmitter is in the nondata state when it is not sending any part of a block and is sending SYN or control characters. The transmit data state is entered when SOH or STX is sent and exists until BP of the block being transmitted is sent. The transmit side also sends receive control characters for the receive side and interspersed these control characters properly in the text portion of a block.

In the start-of-block position the transmitter checks to see if the INV character or any receive control characters are to be sent. If there are, these double-character sequences will be sent continuously. The start-of-block character (ie, SOH or STX) will be sent if there is a block to send; otherwise, the synchronizing control characters will be sent. If the start-of-block character is sent, the transmitter will move to the second character position.

The character to be sent in the second framing position of the first block is the SEL character. Both the terminal and the LCM send the SEL character in the second position after the SOH character. Only the SEL character may be sent at this time. The DEL character will be sent in the second framing position of the second and all succeeding blocks.

After transmitting the start-of-block character and the second character, the transmitter is now in the text position. In this position, receive control characters, text characters, or special control characters may be sent. Only text and EM characters are used to count to the next position. After transmitting 80 text characters or 79 or less text characters and an EM character, the transmitter is ready to send the end-of-block framing character. If the transmitter has not received a correct acknowledgment for the previous block, then the transmitter sends synchronizing characters.

In the end-of-block framing position, the transmitter checks to see if any answer flags are set; if so, it will send the answer. If there is no answer to be sent, the end-of-block framing character is sent (ETB or ETX) followed by the block parity character. During continuous operations, the transmitter starts sending the next block, if there is one; otherwise, synchronizing characters are sent.

If any receive or transmit control characters are waiting, they are sent at this time. If there are no answers to be sent and if the answer timer has not expired, synchronizing characters will be sent. When the answer timer expires, the proper transmit control character will be sent. If the CAN sequence or the last block is acknowledged, the transmitter will send the start-of-block character of the next block.

The RM sequence may be sent by the LCM in response to a block of a message; in this case, the CAN sequence sent after receipt of the RM sequence will cancel the message. If WBT is received as an answer to the CAN sequence, the CAN sequence will be repeated at REP time intervals until WBT is no longer received and the ACK2 sequence is received.

The CAN sequence timing is identical to the REP sequence timing procedure. A REP sequence will be sent when an answer for the block is not received in the allowable response time. Each REP sequence will be repeated by the terminal up to three times if no reply is received. If no answer is received after the REP sequence has been sent three times, a no-reply alarm is activated and the terminal will continue to send the REP sequence at the proper intervals. The TAC will alarm after three REP sequences have been sent and will continue to send REP sequences at the proper intervals. If the previous ACK sequence is received in response to a transmitted block or in answer to a REP sequence, the block will be retransmitted.

When the end-of-block framing sequence is sent, timing is started for an answer and the next block is transmitted. When the 82nd character or the EM character of this block is sent and an answer for the previous block has not been received, SYN characters will be transmitted until the answer timer expires. If the answer is received and it is the proper ACK sequence, the block is transmitted with the end-of-block framing sequence ETB-BP or ETX-BP. If WBT is received or if the answer timer expires before the 82nd character or the EM character is transmitted, the transmitter will wait until the 82nd character or the EM character is sent before sending the REP sequence.

Normally, the expected answer timer would expire before the last data character of the following block is sent. The transmitter waits until the last data character is transmitted before transmitting the REP sequence for the answer to the previous block.

It should be noted that after the ETX-BP sequence has been sent, the message cannot be canceled by the transmitter if the expected ACK sequence has been received. If the last block of a message has been acknowledged with the expected ACK sequence, the CAN sequence can be sent but it will not cancel the message. The answer to the CAN sequence sent after the last block of a message has been acknowledged will be the ACK2 sequence. This acknowledgment merely serves as an ACK reset, requiring the receiver to respond to the next block transmitted with the ACK1 sequence. In synchronous operation, the ACK's are alternated, first ACK1 and then ACK2, for alternate blocks. The receiver sends alternate ACK's and the transmitter expects alternate ACK's as answers for transmitted blocks. When the transmitter sends the CAN sequence, the receiver answers with the ACK2 sequence; the next ACK sequence sent by the receiver as an answer for a block will be the ACK1 sequence. The transmitter will expect the ACK1 sequence as the answer for the first block sent after sending the CAN sequence.

24.9.2 Receive Mode. In continuous operation, character synchronization must be established and maintained with the transmitter before data reception can begin. The proper block framing character is STX after detection of SOH and periodically for each block until ETX is detected.

In the start-of-block position the receiver accepts synchronizing characters, receives control characters, and transmits control characters and the INV character, or the proper SOH or STX character with the exception of the case where the preceding block was in error. In this case, if the last received block is to be acknowledged with NAK, the receiver will ignore a valid SOH or STX character (if either is received immediately after the BP character of an errored block) and return to the start-of-block framing character position. Between messages, the only acceptable character that can make the transition from the nondata to the data state for the receiver is SOH. After having received an SOH character in the first block, the receiver looks for an STX character in the first block position in each succeeding block

until either the ETX character or a CAN sequence has been received and acknowledged. Message integrity is maintained by requiring that end-of-block framing character sequence accepted last is ETB-BP. If this requirement is met, STX is accepted and the second framing character is expected.

The acceptable characters in the second framing position are the even parity select (SEL) character, or the delete (DEL) character. If the second character is not even parity, the receiver will ignore the block and wait for the REP or CAN sequence. The second framing character will be additionally checked to determine that it is neither SYN nor one of the framing characters (SOH, STX, ETB, ETX), nor one of the transmit or receive control characters. If the receiver determines the character to be one of these characters, the block is ignored and the receiver waits for the REP or CAN sequence.

After receiving a valid SOH, the next framing character must be the SEL character. The TAC will detect an error if the SEL character is part of the "select character set" (Table B-III), but the terminal has not been assigned that particular select character. In this case the TAC will set the NAK flag.

The second framing character of all except the first block of a message is a DEL character. The TAC will validate this character in the same manner as it does the SEL character. If this character is accepted the receiver will move to the text character position.

In the text character position, only odd parity data characters, even parity receive control characters, and even parity special control characters are allowed. The receive control characters and the special control character INV must be double-character sequences.

The NAK flag will be set if a double-character sequence is broken, or if an even parity transmit control character is received or an even parity data character is received. When the NAK flag is set, it will not be used to update the response until after receipt of block parity for that block.

If a framing control character or a synchronizing character is received in the text character position, the receiver will ignore the block, go to the waiting state, and wait for the REP or CAN sequence.

Reception of data characters will be continued until the receiver reaches the end-of-block framing position. The receiver is in the end-of-block framing position when 80 text characters or 79 or less text characters and the even-parity EM character are received. It should be noted that the even-parity EM character is treated as a text character.

In the end-of-block framing position the acceptable characters are ETB, ETX, SYN, receive control, and transmit control characters. The situation of receiving SYN or transmit control character sequences, before receiving the end-of-block framing character is encountered when the transmitting station has not received an answer for the previous block. Special control INV is also acceptable at the end of block framing position.

The BP position of the receive block is established when ETB or ETX is accepted. The next character is BP and is compared with the locally generated BP framing character. If they do not compare, the NAK flag is set. If they do compare and if the NAK flag has not been previously set, the proper ACK flag is set and the receiver returns to the start-of-block framing of the next block. If the NAK flag is set, the receiver returns to the start-of-block framing position of the same block which will be retransmitted.

If the received BP compares with the generated BP, and the NAK Flag has not been set previously, the block is accepted. When the block is accepted, it must be answered. If the receiver cannot accept any additional blocks at this time, it may halt the distant transmitter by answering the received block with the WBT sequence. If this delay in ability to accept another block continues, then the next sequence expected to be received is the REP sequence. Upon receiving the REP sequence, the receiver will answer with the WBT sequence, and this will continue until the receiver is able to accept another block. When the receiver is ready to accept blocks again, it answers the received REP sequence with the acknowledgment for the last accepted block. If no answers are expected from a subscriber, and an answer is received, the receiver returns a dual INV sequence.

24.10 STANDARD CODE. The PSN will support Mode I controlled links using 8-bit, odd-parity, ASCII, code text characters and 8-bit, even parity, DCS AUTODIN control code for control characters. Refer to Tables B-II and B-III.

In this code the eighth (parity) bit will always maintain odd-character parity for text characters. The standard code used on Mode I controlled links for generation and recognition of control characters shall conform to Table B-III, Columns 0 and 1. The sense of the eighth (parity) bit in this case shall always maintain even character parity.

24.11 MODE I DATA FORMATS. Figure B-3 indicates the Mode I data formats for continuous operation. Transmit and receive control characters are shown in various conditions. The following items are illustrated in this figure:

a. One Way Synchronous Operation
b. Special Control Character EM - End of Medium
c. Receive Control Character RM - Reject your Message
d. Transmit Control Character REP - Reply
e. Transmit Control Character WBT - Wait Before Transmitting
f. Transmit Control Character CAN - Cancel
g. Special Control Character INV - Invalid
h. Valid/Invalid Framing Character
i. Valid/Invalid Text Characters
j. Synchronous Characters in 83rd Character Position
k. Incorrect Block Parity
l. Receive Control Characters in Text Character Position
m. Full Duplex Synchronous Operation

Mode I terminal subscribers must enter a heading block in order to initiate a network connection. Once the connection is established, Mode I header information will be passed through the network in a transparent manner; ie, no distinction will be made between data contained in a header block and data contained in information blocks by the AUTODIN II network. The data in the heading block is in accordance with the THP command procedures described in Section 27.

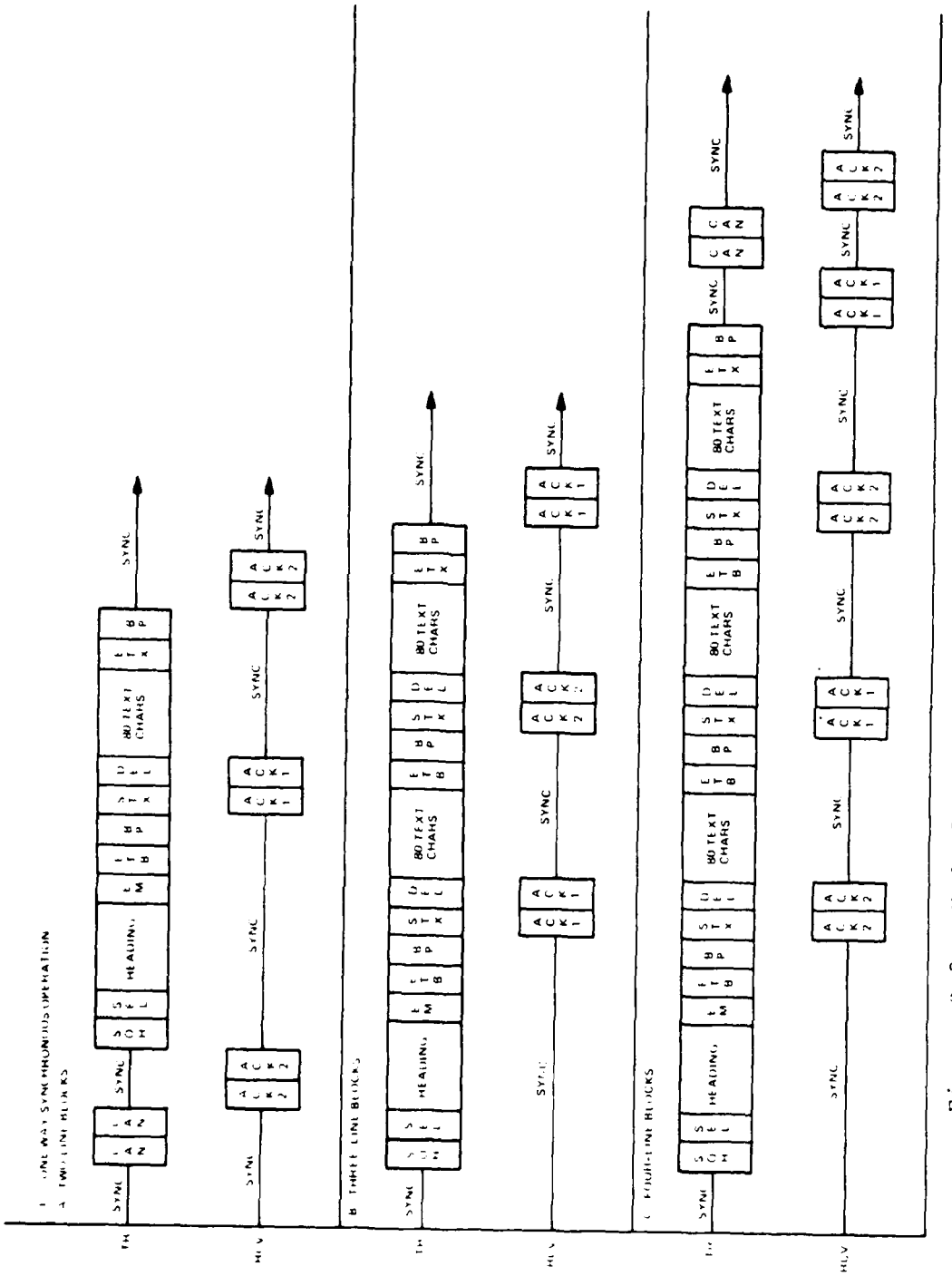


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 1 of 18)

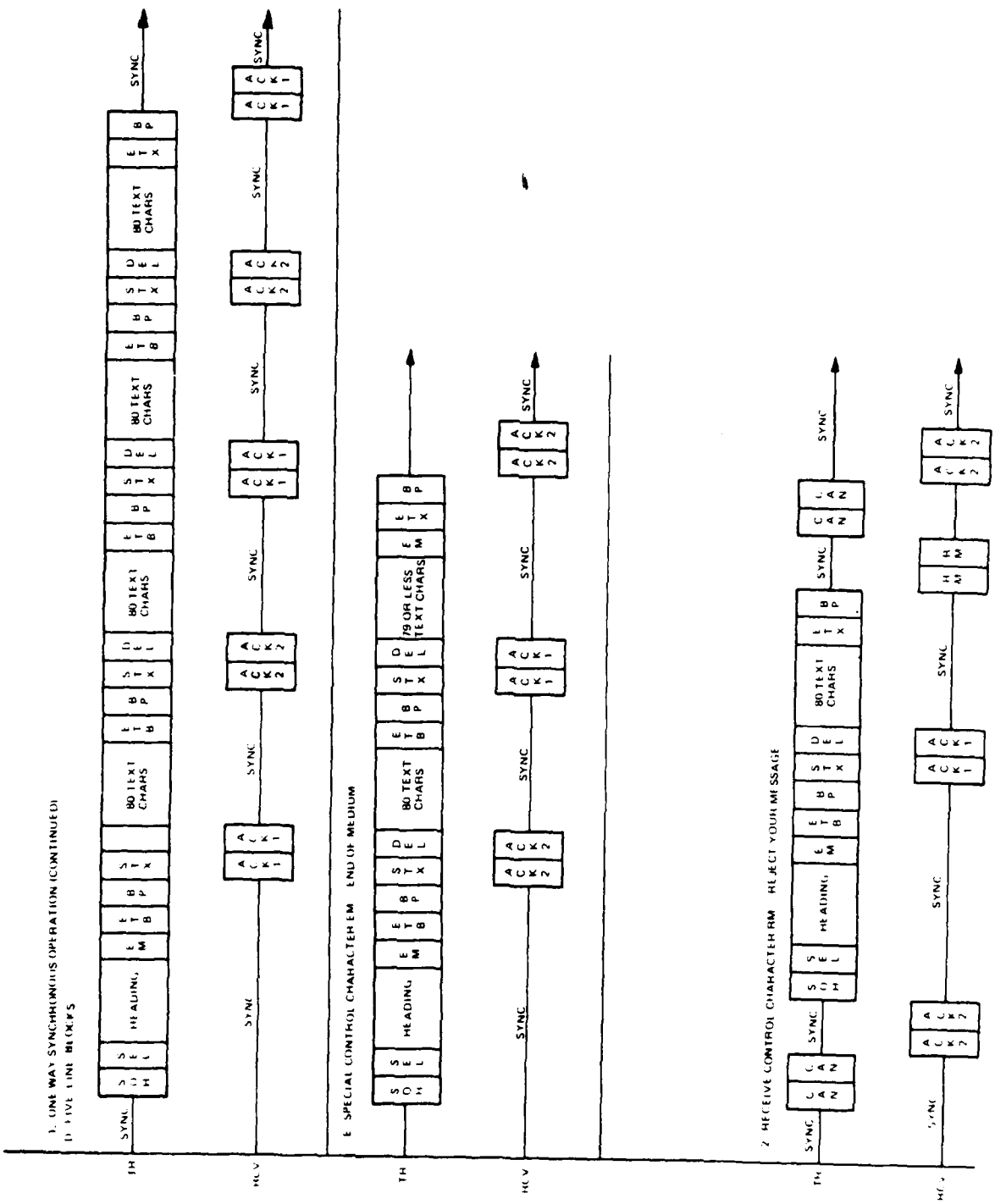


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 2 of 18)

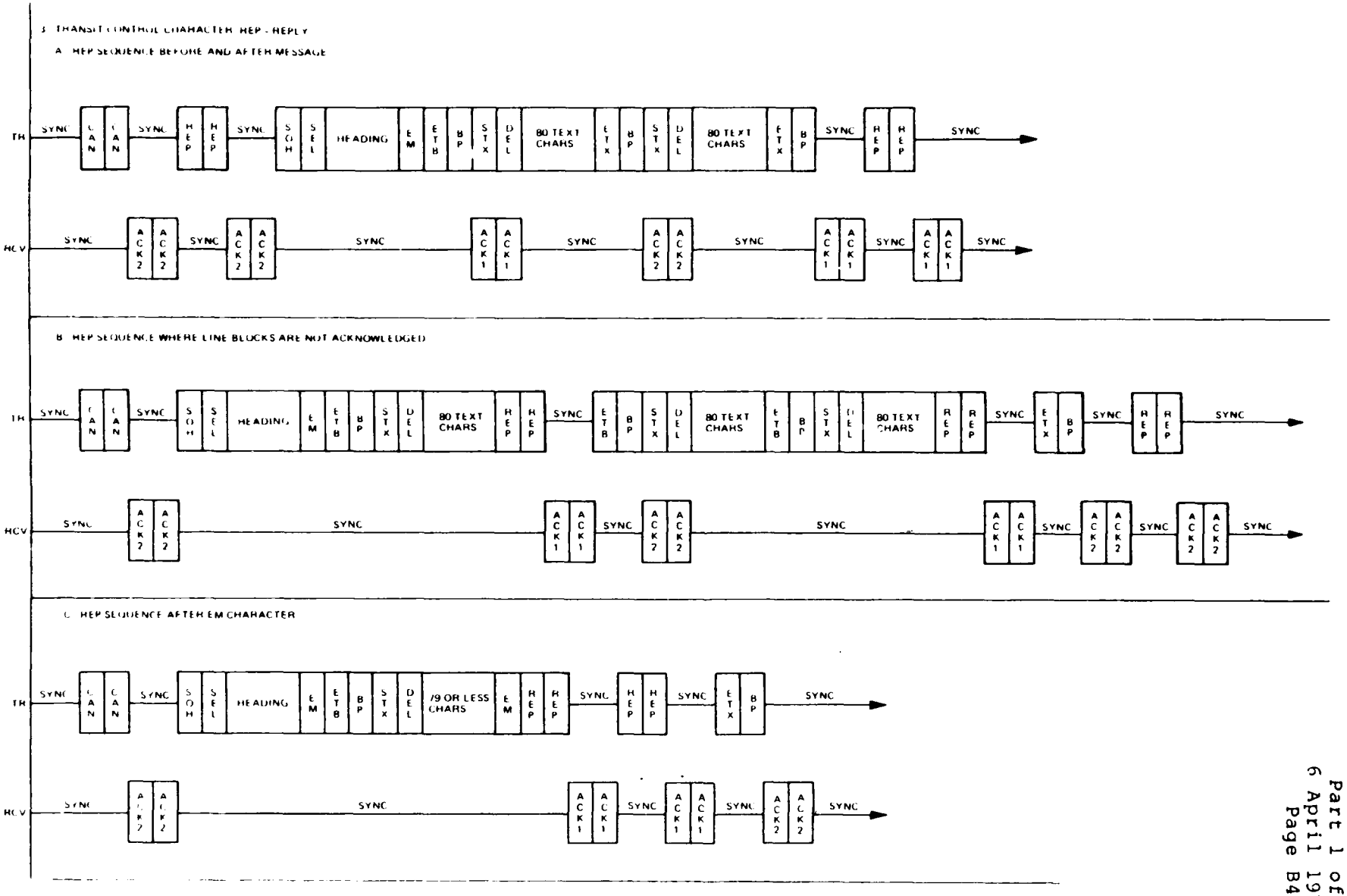


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 3 of 18)

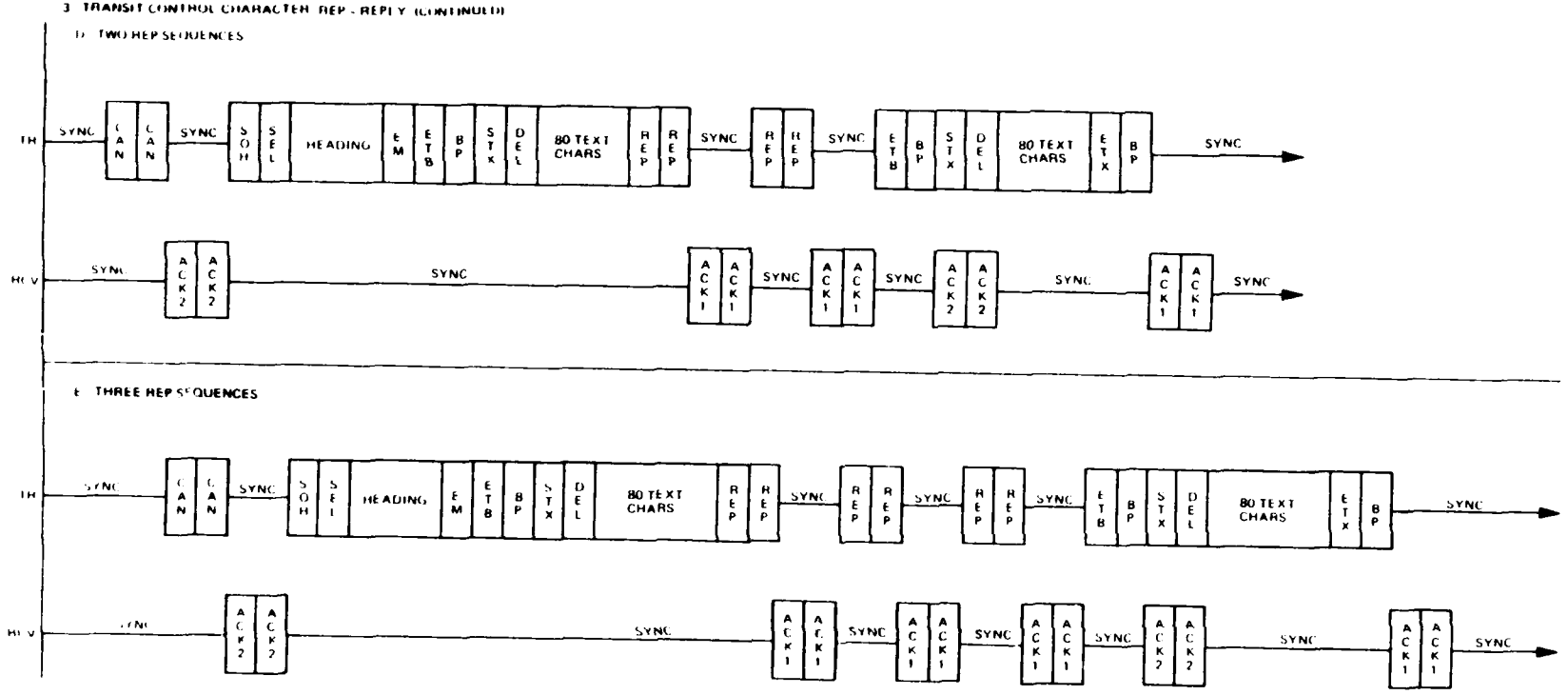


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 4 of 18)

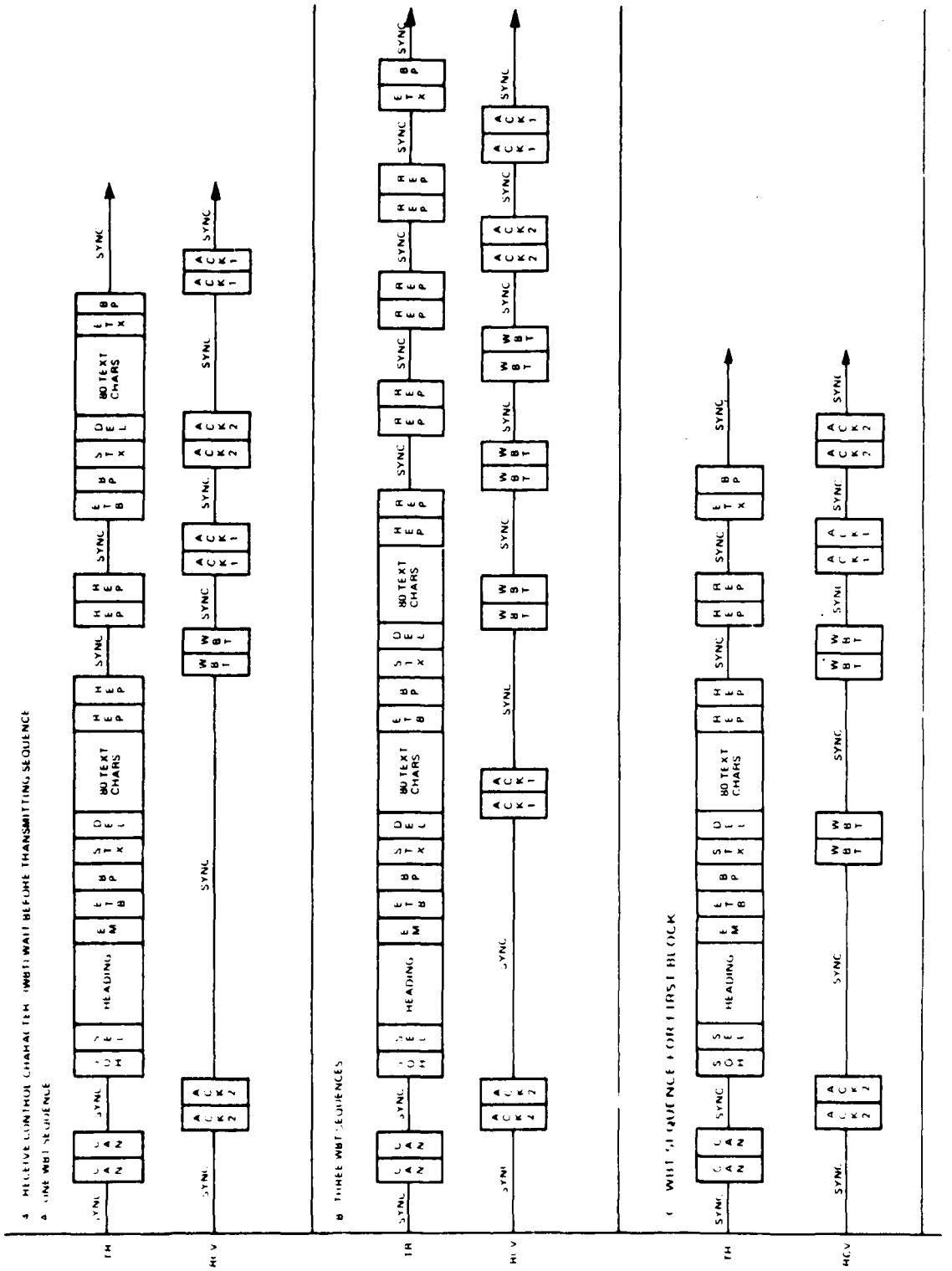


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 5 of 18)

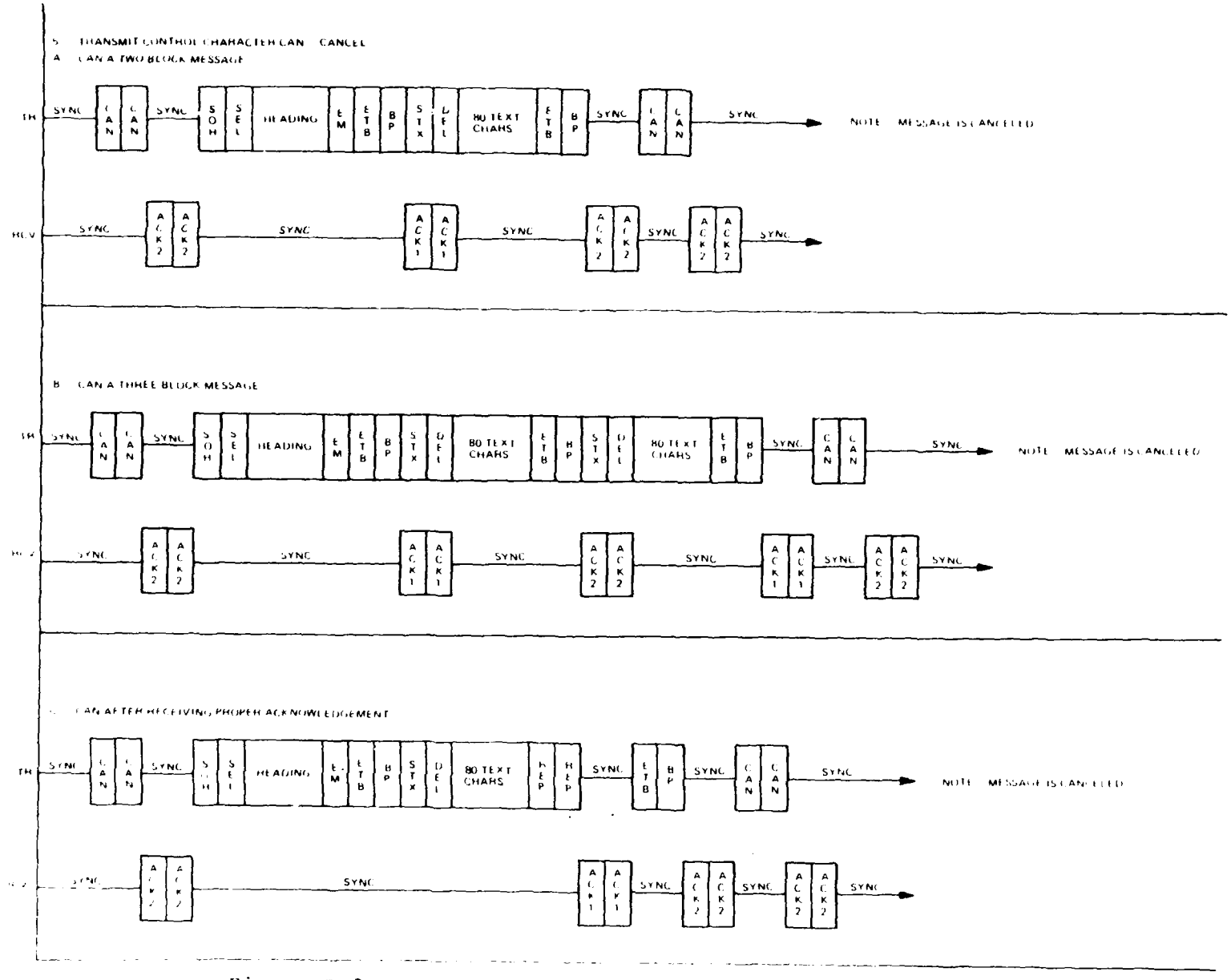


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 6 of 18)

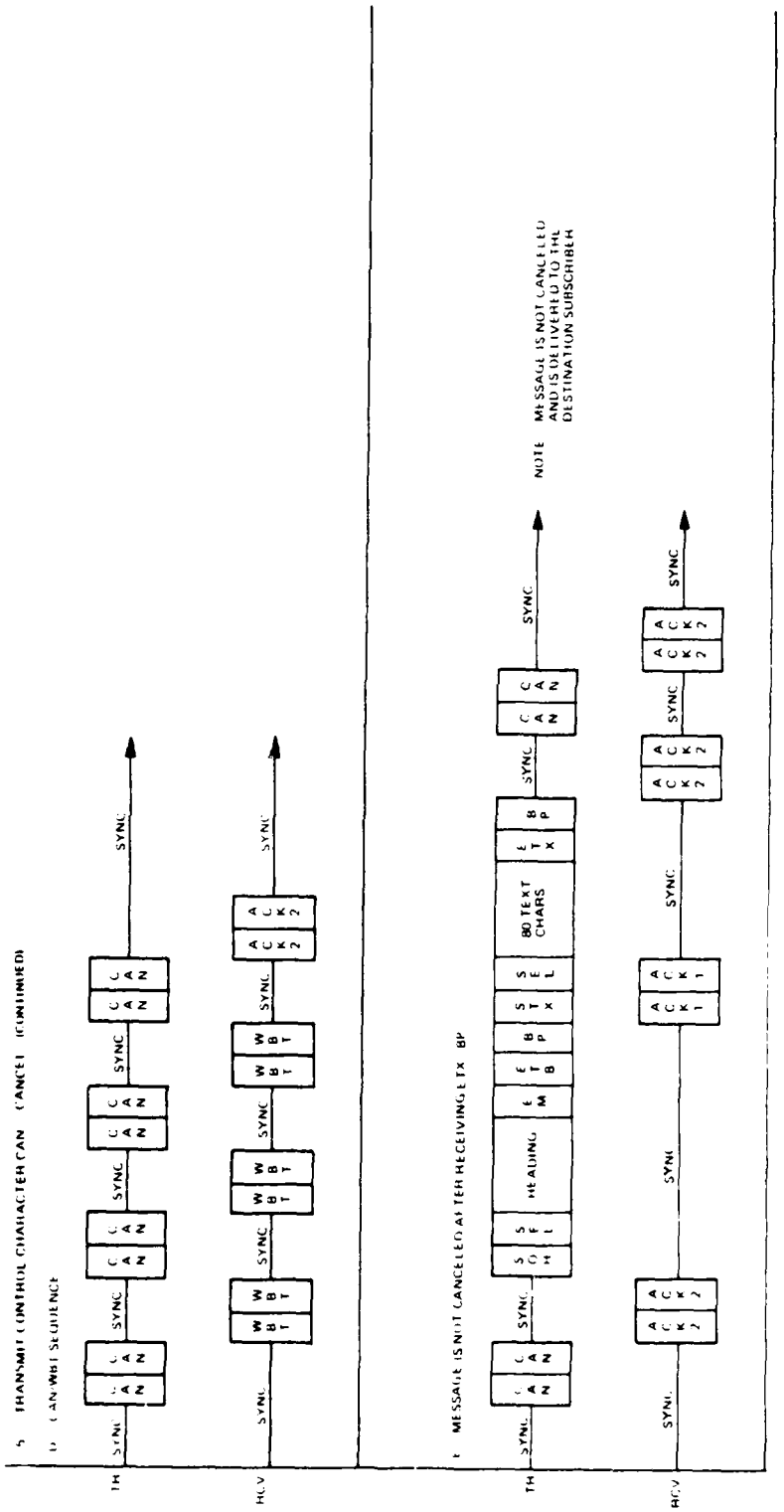


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 7 of 18)

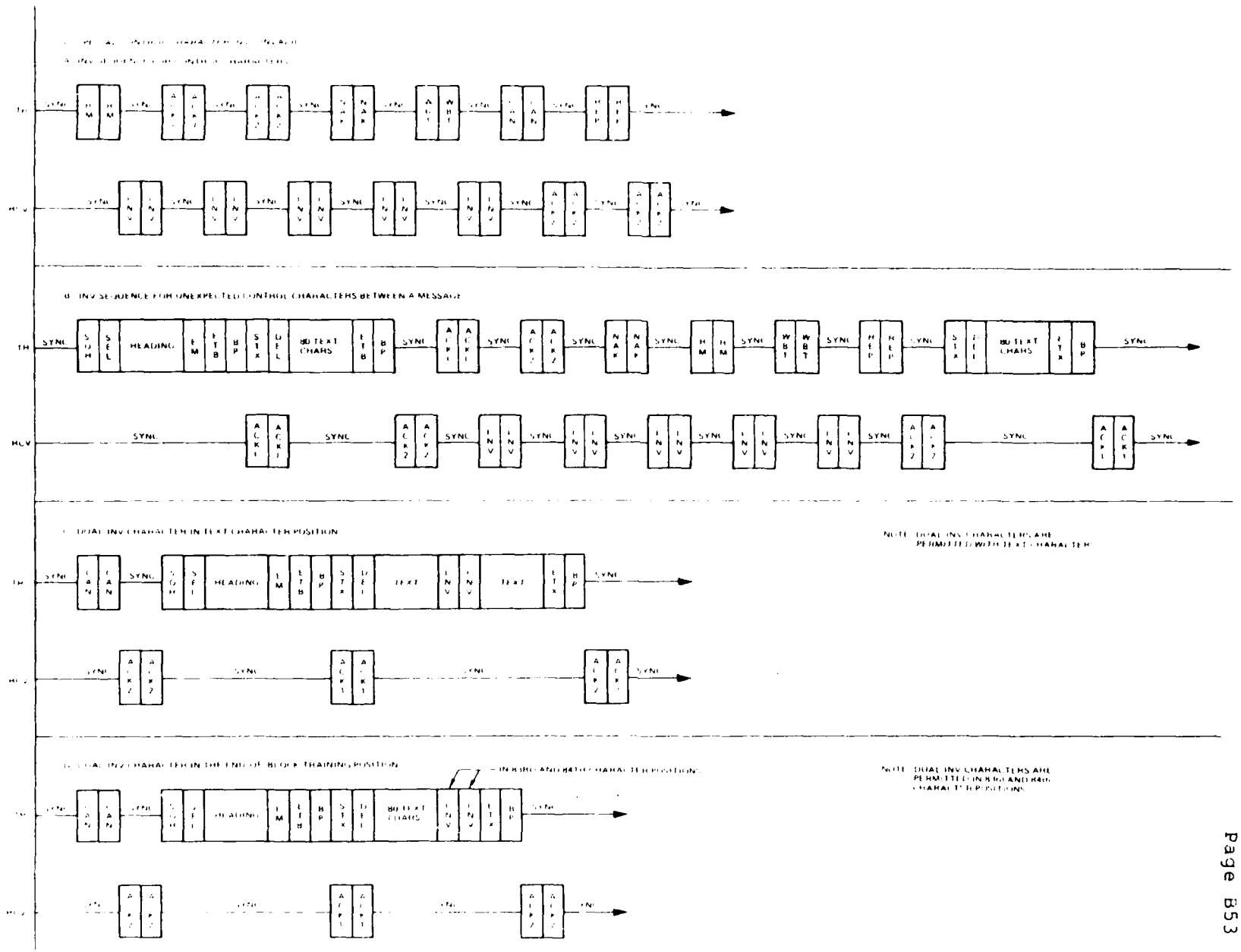


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 8 of 18)

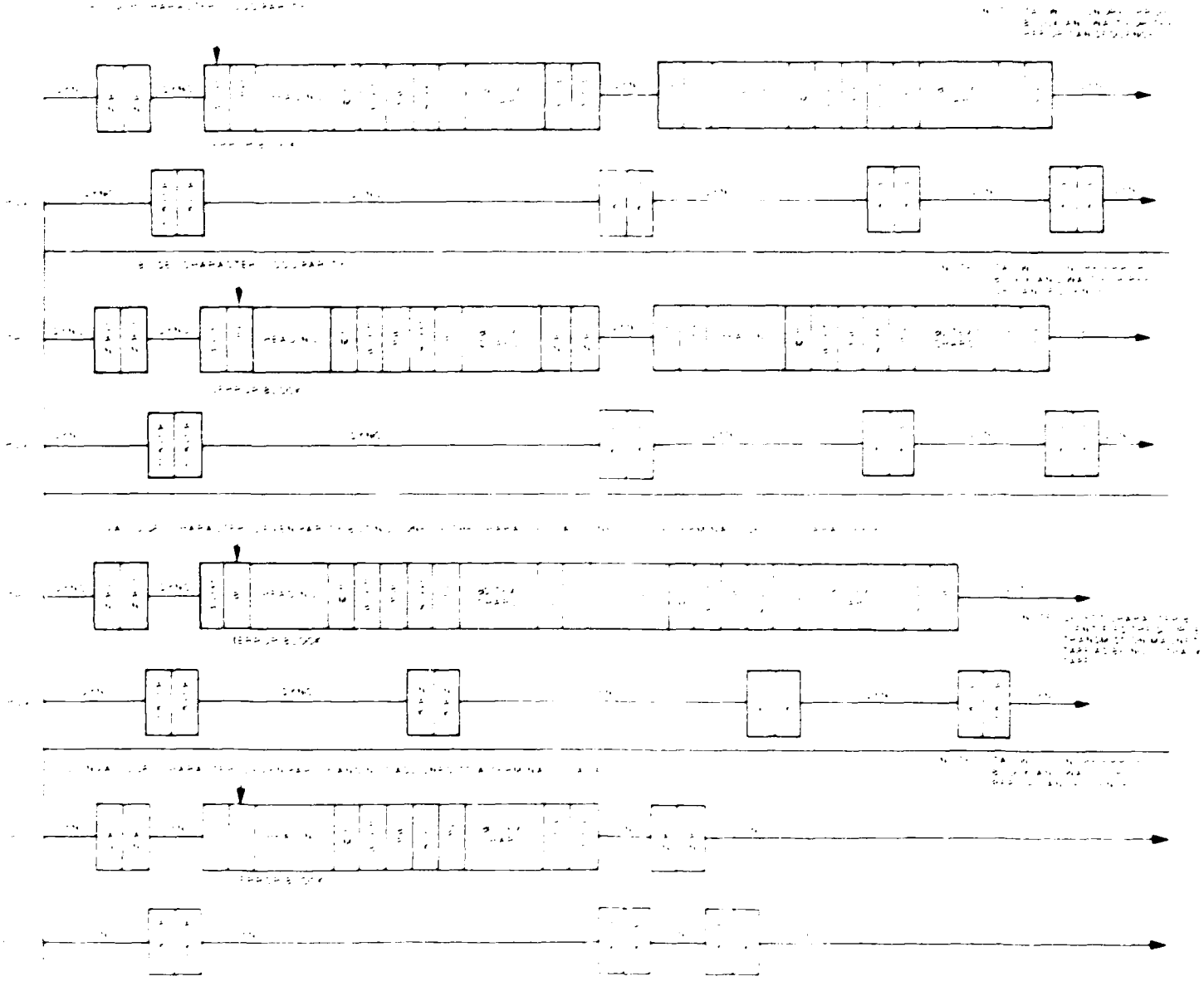


Figure 5-3. Mode 1 Data Formats - Continuous Operation
(Sheet 3 of 13)

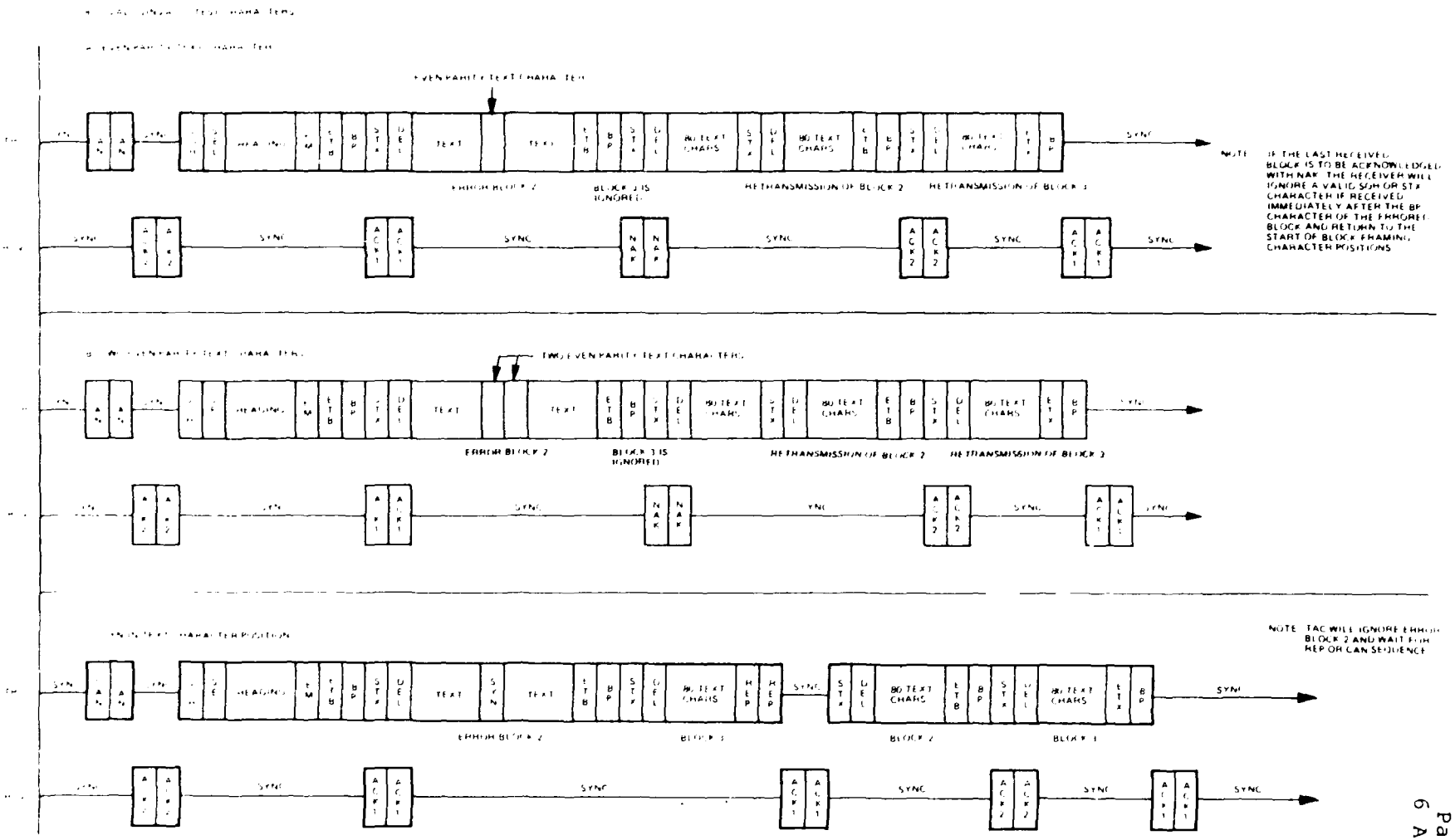


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 10 of 18)

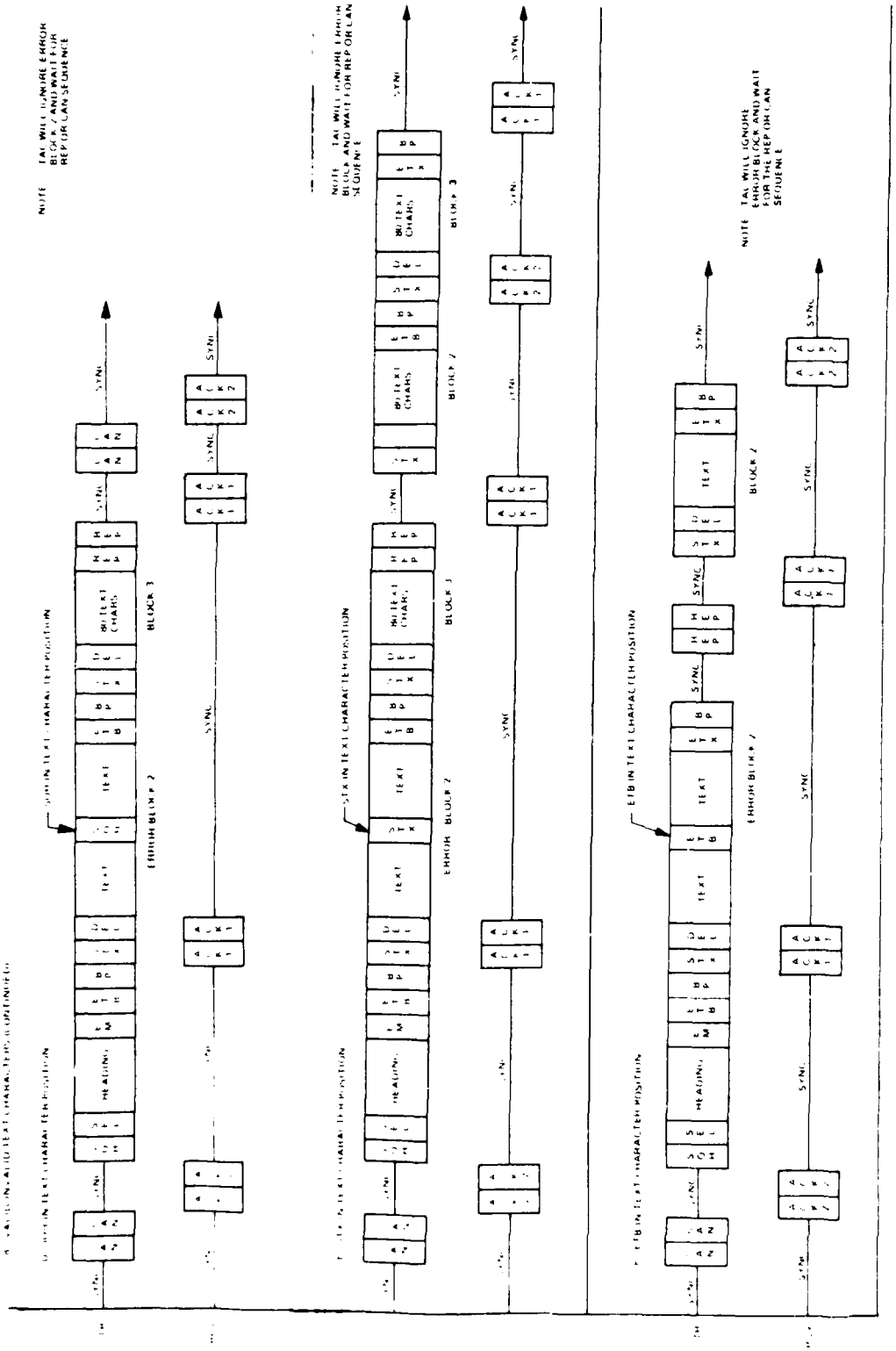


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 11 of 18)

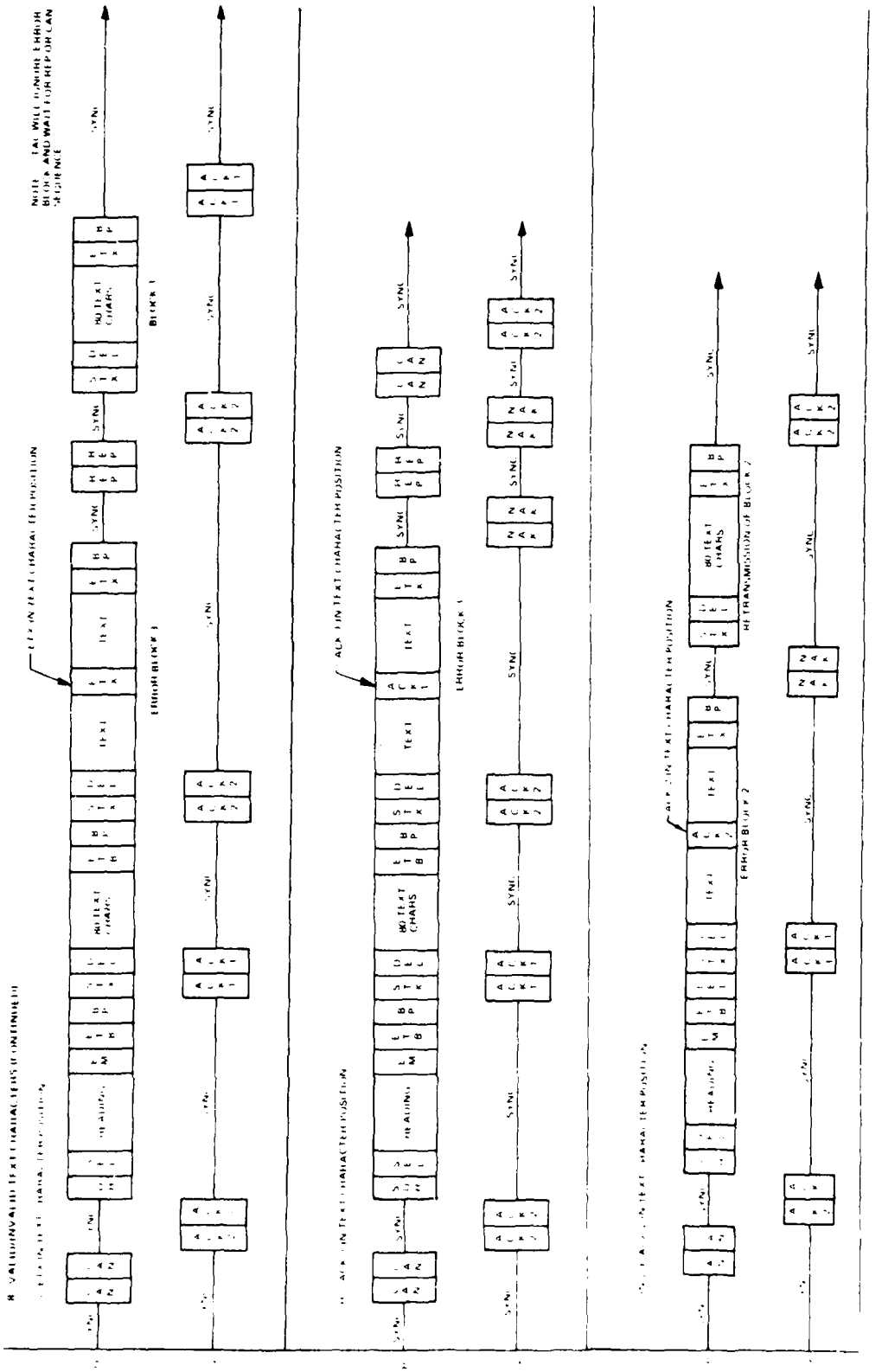


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 12 of 19)

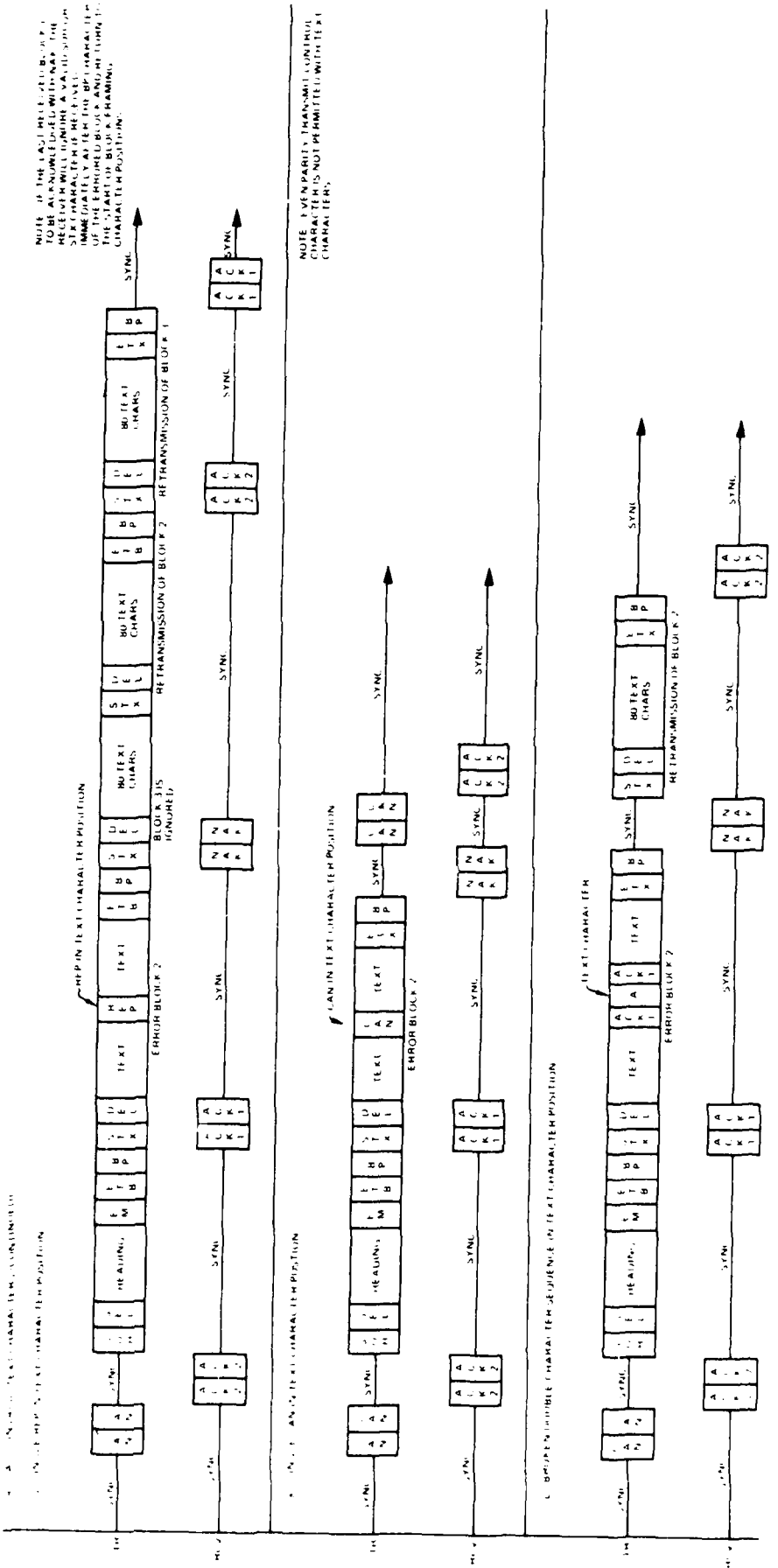


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 13 of 13)

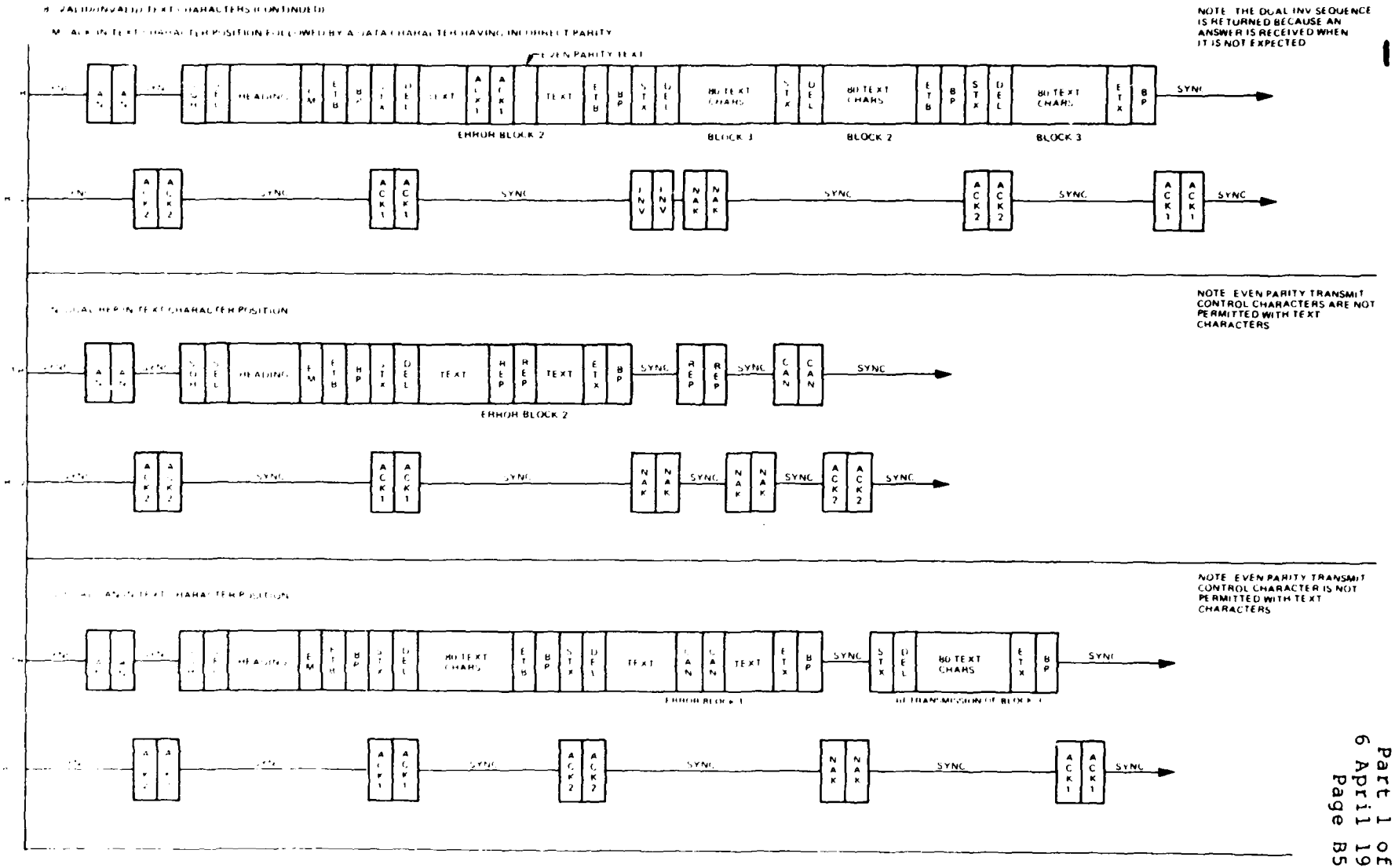


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 14 of 18)

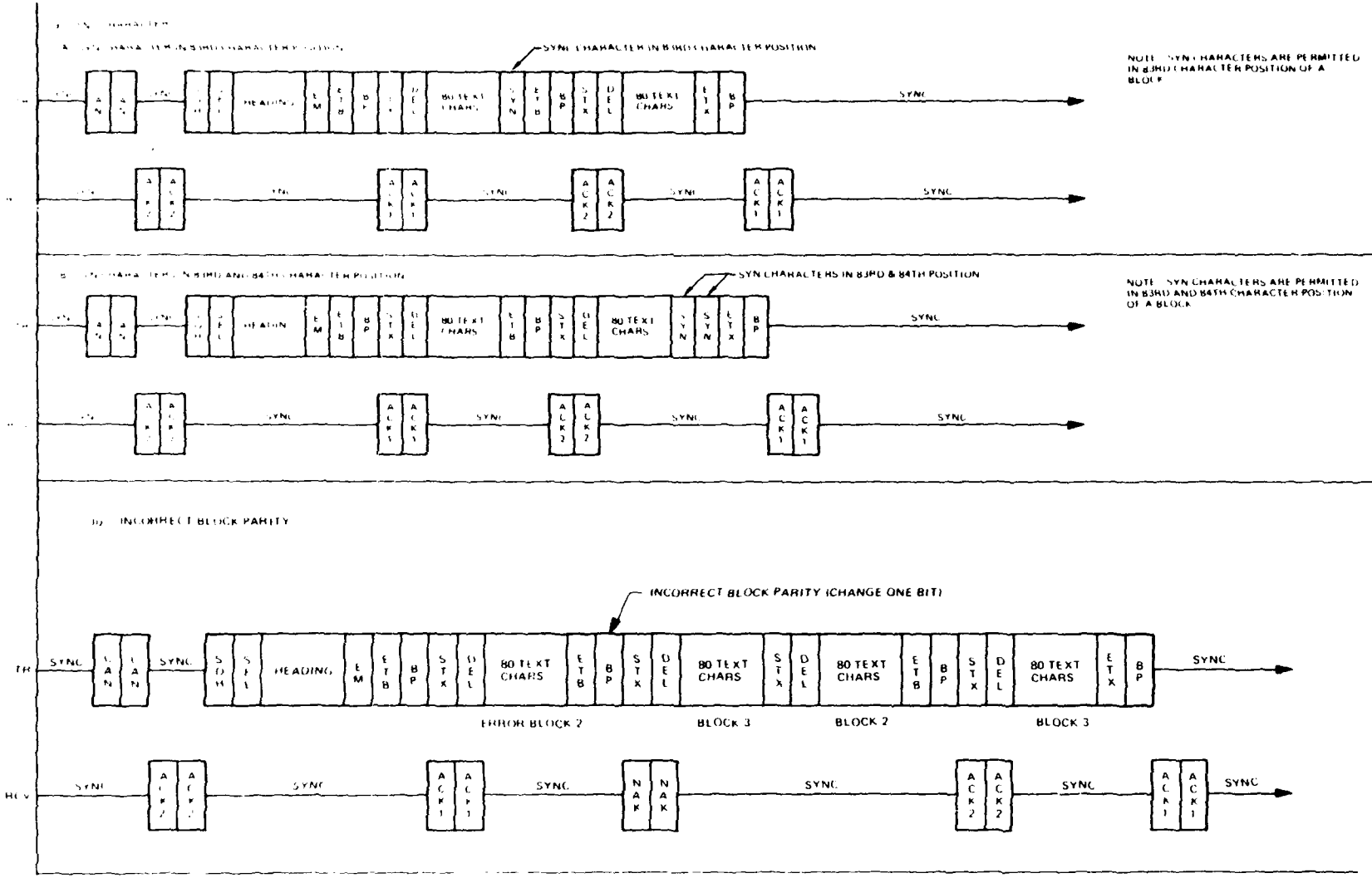


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 15 of 18)

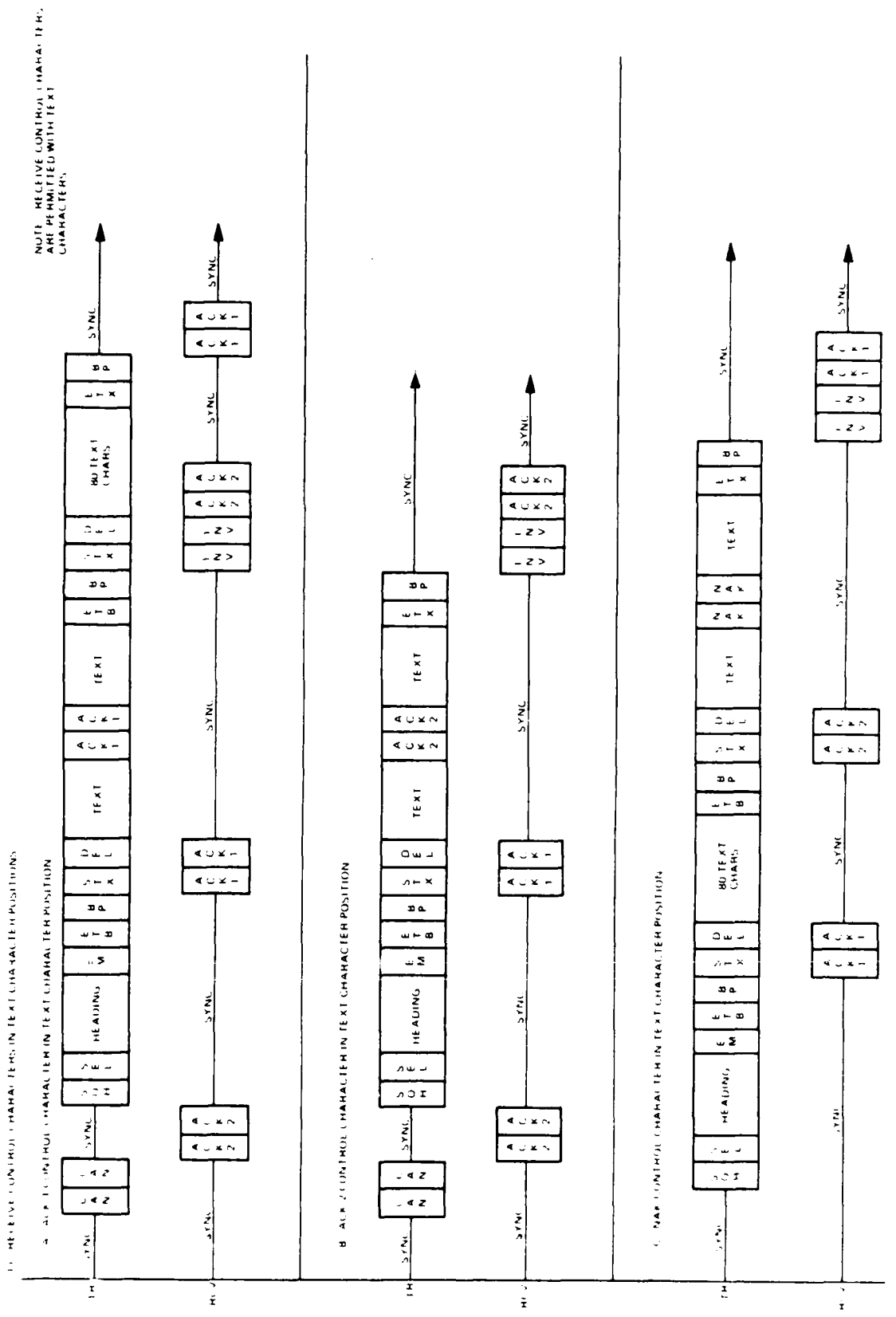


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 16 of 18)

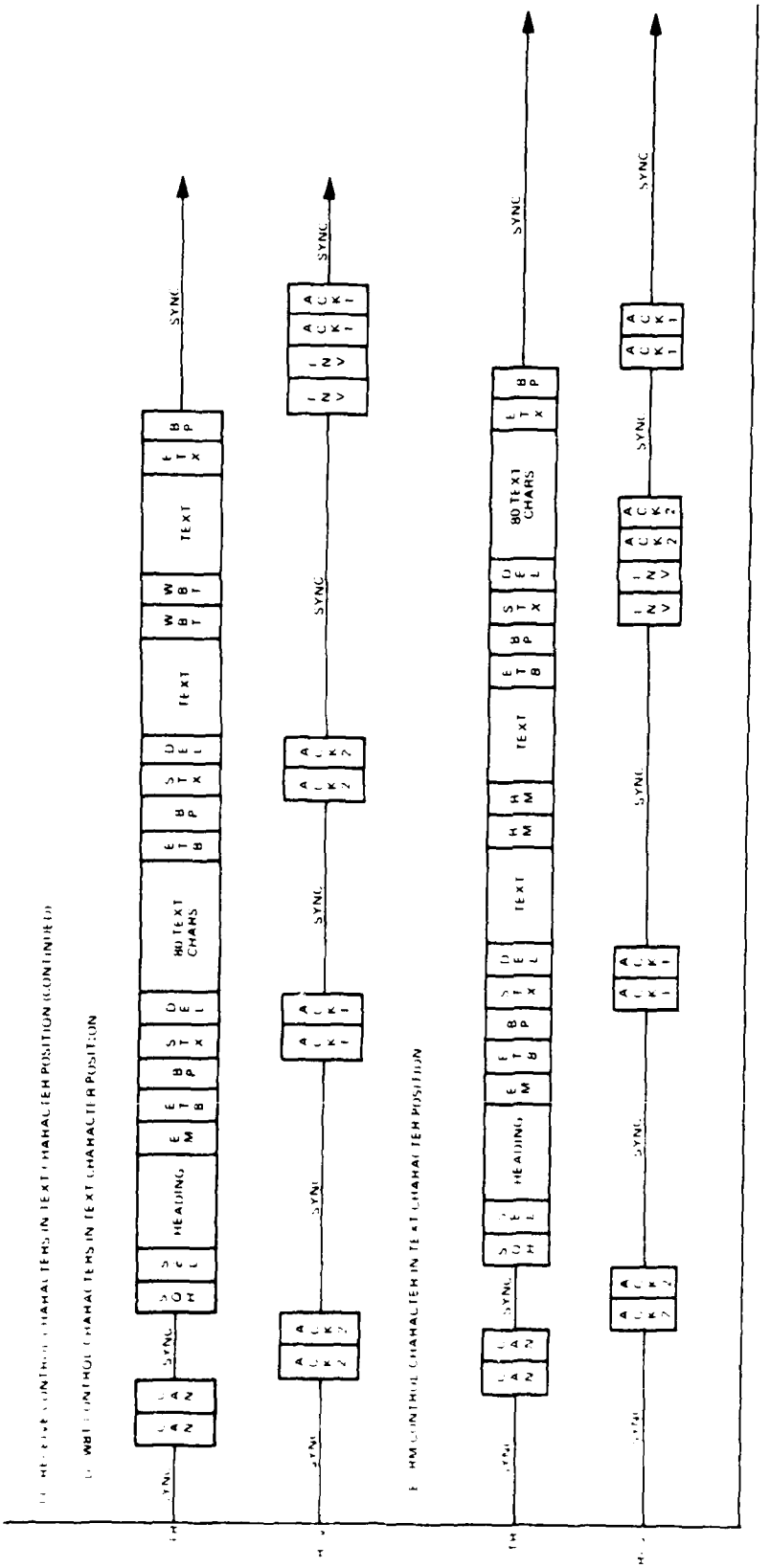


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 17 of 18)

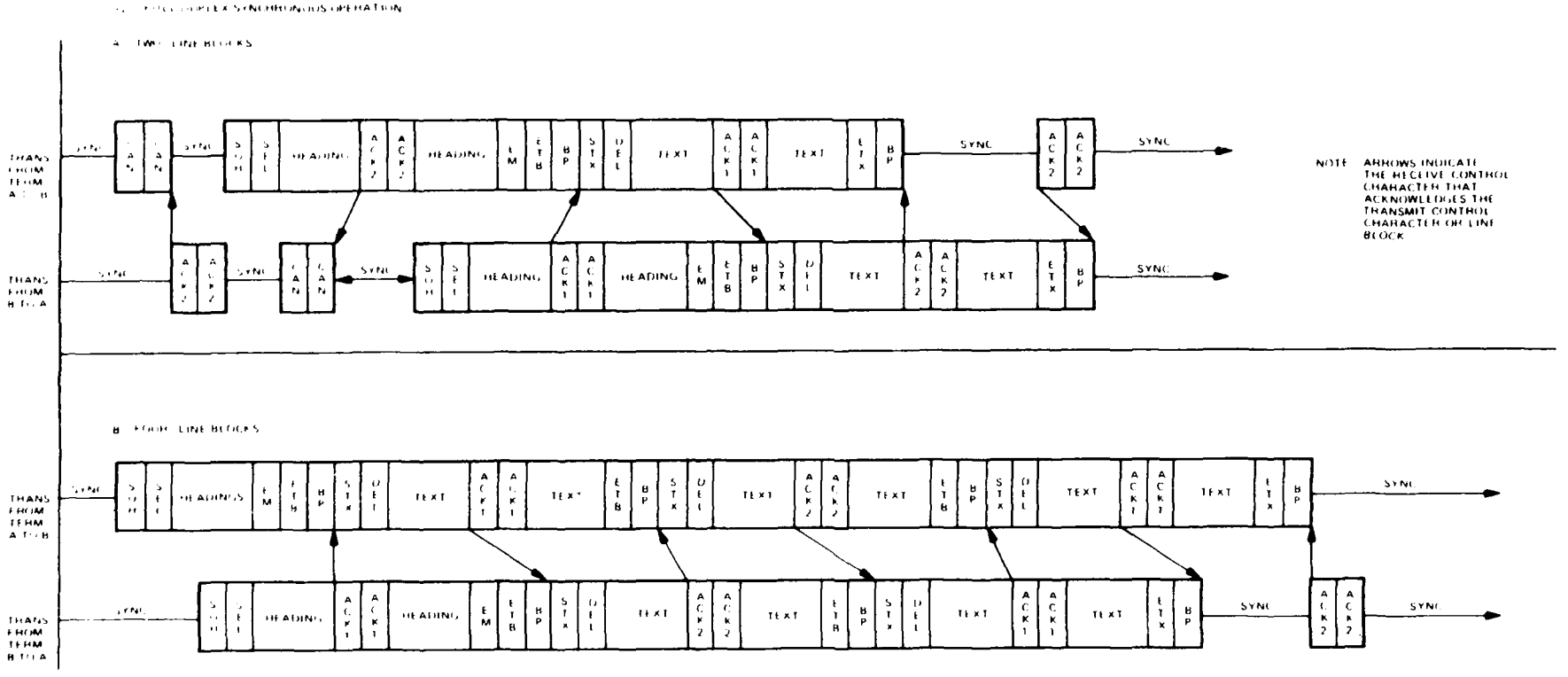


Figure B-3. Mode I Data Formats - Continuous Operation
(Sheet 18 of 18)

SECTION 25 - MODE IB LINK PROTOCOL

25.1 INTRODUCTION. Mode IB is a character-oriented synchronous type of link control which uses character parity and block parity checking along with retransmission of errored messages to achieve an error detection and correction capability. AUTODIN II will operate with subscribers conforming to the Two-Way Alternate Point-to-Point link control procedures described in documents referenced below. This mode is used by subscribers who employ Binary Synchronous Communications (BSC) procedures.

25.2 APPLICABLE DOCUMENTS

a. Binary Synchronous Communications, IBM Order No. GA27-3004-2, dated October 1970.

b. American National Standards Institute (ANSI) X3.28-1971 - Procedures for the use of Communication Control Characters of American National Standard Code for Information Interchange in Data Communications Links, dated 10 March 1971.

25.3 MODE IB CHARACTERISTICS

a. Block-by-block coordination

b. Synchronous transmission

c. Half-duplex data transmission (two-way alternate)

d. Character parity and block parity (BCC)

e. Transmission code 8-bit ASCII (seven data bits plus one parity bit)

f. Odd parity for all control characters and data characters

g. Each block is of variable length

h. Number of blocks per message is variable

i. Characters are transmitted serially bit-by-bit, with the low order bit first and the parity bit last

j. A message will consist of a header block preceded with SOH characters and ending with ETB and BCC. Also, the last block begins with STX and ends with ETX and BCC. Intervening blocks begin with STX and end with ETB and BCC

k. The character parity is checked and generated by the Line Termination Unit (LTU), both at the input and at the output

l. The status of the check is passed on to LCM software

m. The block parity is checked and generated by the LCM, and the status is made available to TAC software

n. The status information that will be made available to TAC software is:

1. Loss of synchronization
2. Character error
3. Block error
4. ETB, ETX
5. Synchronization established
6. Byte count equal to zero

o. LCM will not initiate recovery or acknowledgment procedures other than inform TAC with the above-mentioned statuses

p. All actions resulting from the above statuses are initiated by TAC software

q. LCM will recognize and remove all SYNC characters from the input data stream. Indication that LCM is receiving synchronization will be available for status reporting.

25.4 BINARY SYNCHRONOUS COMMUNICATIONS. Binary Synchronous Communications (BSC) procedure provides a set of rules for synchronous transmission of binary coded data. All data in BSC is transmitted as a serial stream of binary digits. Synchronous communications means that the active receiving station on a communications channel operates in step with the transmitting station through the recognition of a specific bit pattern (sync pattern) at the beginning of each transmission.

25.5 POINT-TO-POINT OPERATION. A point-to-point data link consists of a communications facility between only two stations. For point-to-point operation, a contention situation exists whereby both stations can attempt to use the communication line simultaneously. To minimize this possibility, a station bids for the line using the ENQ control character. Refer to the Mode IB formats in paragraph 25.12. The SYNC SYNC ENQ sequence (SYNC SYNC represents the synchronous idle characters) provides the means for controlling the line. If simultaneous bidding occurs, one station must persist in its bidding attempt to break the contention condition. A station receiving this sequence (and ready for message reception) replies with SYNC SYNC ACK0. If the station is not ready to receive, it replies with either of the following:

a. SYNC SYNC NAK (negative acknowledgment)

b. SYNC SYNC WACK (wait before transmit positive acknowledgment).

To avoid the problems associated with simultaneous transmission requests, each station is assigned a priority - primary or secondary. The higher priority (primary) station sends an ENQ to acquire the idle line. It will continue to do so until it receives an affirmative response or until the retry limits of the primary station are reached. If the primary station receives an ENQ and it has not initiated a request for the line, then it replies with ACK0 (if ready to receive), WACK, or NAK. Thus the secondary station can gain control of the line for a transmission only when the line is left free by the primary station.

Message transmission is ended and the line is returned to an idle state by the transmission of SYNC SYNC EOT. The station sending SYNC SYNC EOT will not send an initialization sequence before 3 seconds have elapsed, thus allowing the other station to bid for the line.

25.6 DATA LINK CONTROL CHARACTERS. Mode IB protocols control data links through the use of the following control characters and sequences:

a. SYNC - Synchronous idle
b. SOH - Start of heading
c. STX - Start of text
d. ITB - End of intermediate transmission block
e. ETB - End of transmission block
f. ETX - End of text
g. EOT - End of transmission
h. ENQ - Enquiry
i. ACK0/ACK1 - Alternate affirmative acknowledgment
j. NAK - Negative acknowledgment
h. DLE - Data link escape
l. RVI - Reverse interrupt
m. TTD - Temporary text delay
n. DLE EOT - Disconnect sequence for switched network.

The bit configuration of Mode IB control characters is shown in Tables B-IV and B-V. Refer to Mode IB formats in 25.12.

25.6.1 SYNC - Synchronous Idle. This character is used to establish and maintain synchronization and as a time fill in the absence of any data or other control character. Two contiguous SYNC's at the start of each transmission (SYNC SYNC) are referred to as the character-phase synchronization pattern.

Table B-IV. USASCII Character Assignments in Mode IB or BSC Protocols

Bits b_7 b_6 b_5					$0\ 0\ 0$	$0\ 0\ 1$	$0\ 1\ 0$	$0\ 1\ 1$	$1\ 0\ 0$	$1\ 0\ 1$	$1\ 1\ 0$	$1\ 1\ 1$
b_4	b_3	b_2	b_1	COLUMN / ROW	0	1	2	3	4	5	6	7
0	0	0	0	0	NUL	DLE	SP	0	@	P	`	p
0	0	0	1	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	2	STX	DC2	"	2	B	R	b	r
0	0	1	1	3	ETX	DC3	#	3	C	S	c	s
0	1	0	0	4	EOT	DC4	$	4	D	T	d	t
0	1	0	1	5	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	6	ACK	SYN	&	6	F	V	f	v
0	1	1	1	7	BEL	ETB	'	7	G	W	g	w
1	0	0	0	8	BS	CAN	(	8	H	X	h	x
1	0	0	1	9	HT	EM	)	9	I	Y	i	y
1	0	1	0	10	LF	SUB	*	:	J	Z	j	z
1	0	1	1	11	VT	ESC	+	;	K	[	k	{
1	1	0	0	12	FF	FS	,	<	L	\	l	|
1	1	0	1	13	CR	GS	-	=	M	]	m	}
1	1	1	0	14	SO	RS	.	>	N	^	n	~
1	1	1	1	15	SI	US	/	?	O	_	o	DEL

Table B-V. Control Character Conversion Chart

Data Link Character	ASCII Character
SYN	SYN
SOH	SOH
STX	STX
ETB	ETB
ETX	ETX
EOT	EOT
ENQ	ENQ
ACK0	DLE0
ACK1	DLE1
NAK	NAK
DLE	DLE
ITB	US
WACK	DLE;
RVI	DLE<
TTD	STX ENQ

NOTE: Control characters ACK0, ACK1, WACK, RVI, and TTD are two character sequences.

25.6.2 SOH - Start of Heading. This character precedes a block of heading characters. A heading consists of auxiliary information (such as routing and priority) necessary for the system to process the text portion of the message.

25.6.3 STX - Start of Text. This character precedes a block of text characters. Text is that portion of a message treated as an entity to be transmitted through to the ultimate destination without change.

25.6.4 ETB - End of Transmission Block. The ETB character indicates the end of a block of characters started with SOH or STX. The blocking structure is not necessarily related to the processing format. The block-check character (BCC) is sent immediately following ETB. ETB requires a reply indicating the receiving station's status (ACK0, ACK1, NAK, or, optionally, WACK or RVI).

25.6.5 ITB - End of Intermediate Transmission Block. The ITB character (US in USASCII) is used to divide a message (heading or text) for error checking purposes without causing a reversal of transmission direction. The block check character (BCC) immediately follows ITB and resets the block check count. After the first intermediate block, successive intermediate blocks of the same type (heading or text) need not be preceded by STX or SOH. If one intermediate block is heading and the next intermediate block is text, STX must begin the text block.

Normal line turnaround occurs after the last intermediate block, which is terminated by ETB or ETX. When one of these ending characters is received, the receiving station responds to the entire transmission. If a block check error is detected for any of the intermediate blocks, a negative reply is sent requiring transmission of all intermediate blocks.

All BSC stations must have the ability to receive ITB and its attendant BCC. The ability to transmit the ITB character is a station option.

25.6.6 ETX - End of Text. The ETX character terminates a block of characters started with STX or SOH and transmitted as an entity. The block check character is sent immediately following ETX. ETX requires a reply indicating the receiving station's status.

25.6.7 EOT - End of Transmission. This character indicates the end of a message transmission, which may contain one or more blocks, including text and associated heading. It causes a reset of a station on the line. EOT is also used as an abort signal to indicate a system malfunction or operational situation that precludes continuation of the message transmission.

25.6.8 ENQ - Enquiry. The ENQ character is used to obtain a repeat transmission of the response to a message block if the original response was garbled or was not received when expected. ENQ is also used to bid for the line when using a point-to-point line connection. If the sender wishes to abort a transmission, an ENQ may be inserted following text characters and the block is not terminated with ETB or ETX and BCC. The receiver will discard the transmission. NAK (Negative Acknowledgment) is the reply to the aborted transmission.

25.6.9 ACK0/ACK1 - Affirmative Acknowledgment. ACK0 and ACK1 are the two character sequences DLE0 and DLE1, respectively. Where required, these replies, in proper sequence, indicate that the previous block was accepted without error and that the receiver is ready to accept the next block of the transmission. ACK0 is the positive response to line bid in operation. Mode IB alternately uses ACK0 and ACK1 as affirmative replies. The use of ACK0 and ACK1 provides a sequential checking control for a series of replies.

25.6.10 WACK - Wait-Before-Transmit Positive Acknowledgment. WACK (DLE; in USASCII) allows a receiving station to indicate a temporarily not ready to receive condition to the transmitting station. It can be sent as a response to a text or heading block, line bid (point-to-point with contention), or an ID (identification number) line bid sequence (switched network). WACK is a positive acknowledgment to the received data block or to selection.

The normal transmitting station response to WACK is ENQ, but EOT and DLE EOT (switched network) are also valid responses. When ENQ is received, the receiving station will continue to respond with WACK until it is ready to continue. The ability to receive WACK is mandatory for all stations, but the capability to send WACK is optional.

25.6.11 NAK - Negative Acknowledgment. NAK indicates that the previous block was received in error and that the receiver is ready to accept a retransmission of the erroneous block. It is also the not-ready reply to line bid.

25.6.12 DLE - Data Link Escape. DLE is a control character used exclusively to provide supplementary line control characters, such as WACK (DLE;), ACK0 (DLE0), ACK1 (DLE1), and RVI (DLE<).

25.6.13 RVI - Reverse Interrupt. The RVI (DLE< in USASCII) control sequence is a positive response used in place of the ACK0 or ACK1 positive acknowledgment. RVI is transmitted by a receiving station to request termination of the current transmission because of a high priority message which it must transmit to the sending station. Successive RVI's cannot be transmitted, except in response to ENQ.

The sending station treats the RVI as a positive acknowledgment and responds by transmitting all data that prevents it from becoming a receiving station. More than one block transmission may be required to empty the sending station's buffers.

The ability to receive RVI is mandatory for all stations, but the ability to transmit RVI is optional.

25.6.14 TTD - Temporary Text Delay. The TTD control sequence is sent by a sending station in message transfer state when it wishes to retain the line, but is not ready to transmit. The TTD control sequence (STX ENQ) is normally sent after approximately 2 seconds if the sending station is not capable of transmitting the next text block or initial text block within that time. This 2-second timeout avoids the nominal 3-second receive timeout at the receiving station.

The receiving station responds NAK to the TTD sequence and waits for transmission to begin. If the sending station is still not ready to transmit, the TTD sequence can be repeated one or more times.

This delay in transmission can occur when the sending station's input device has not completely filled the buffer due to inherent machine timings. TTD is also transmitted by a sending station in message transfer mode to indicate to the receiver that it is aborting the current transmission. After receiving NAK to this TTD sequence, the sending station sends EOT resetting the stations to control mode (forward abort).

25.6.15 Disconnect Sequence for a Switched Line - DLE EOT. Transmission of DLE EOT on a switched line indicates to the receiver that the transmitter is going on-hook. Either the calling or the called station may transmit this disconnect sequence. DLE EOT is normally transmitted when all message exchanges are complete and may optionally be transmitted at any time instead of EOT to cause a disconnect.

25.7 ERROR CHECKING. All characters received from the terminal subscriber will be passed to TAC (except for SYNC characters) after they are checked for odd parity by the LCM. If a character parity is detected, the appropriate status information will be set, and the LCM will continue to accept characters until a valid terminating character is received. On detection of ETX, ETB, or ITB, the next succeeding character will be compared to the locally generated longitudinal redundancy check (LRC), and an error status will be generated if the two do not compare.

In general, LRC is a longitudinal redundancy check on the total data bits within a block. An LRC is accumulated at both the sending and receiving ends during the transmission of a block. This accumulation is called the block check character (BCC), and it is transmitted immediately following an ETB, ETX, or ITB character. The transmitted BCC is compared with the accumulated

BCC character at the receiving station for an equal condition. An equal comparison indicates a good transmission of the previous block.

The LRC accumulation is reset by the first STX or SOH character received after a line turnaround. In normal transmission, all characters received after the SOH or STX to the ETB or ETX including control characters are included in the BCC accumulation. Only SYNC characters are not included in the BCC accumulation. Following an ITB BCC, the accumulation resets the block check count.

Refer to 25.12 for Mode IB data formats.

25.8 TIMEOUT REQUIREMENTS. Timeouts are used to prevent indefinite data-link tie-ups due to false sequences or missed turnaround signals by providing a fixed time within which any particular operation must occur. Due to the different requirements for the various operations, four specific timeout functions are provided as follows:

a. Transmit
b. Receive
c. Disconnect
d. Continue

The various timeout requirements of this protocol will not be performed by the LCM. These requirements will be implemented in the TAC software.

25.8.1 Transmit Timeout. There is a nominal 1-second timeout that establishes the rate at which synchronizing idles are automatically inserted into transmitted heading and text data. In normal data, the data is being transmitted over the link in a normal, or nontransparent mode, (data link control characters are recognized as such without being preceded by a Data Link Escape (DLE) character). Two consecutive SYNC-idle characters (SYNC SYNC) are inserted every second. If business machine clocking is used, DLE SYNC insertion is required at least every 31 characters to ensure maintenance of bit synchronization in the event of transitionless data. There must be at least 54 characters between each DLE SYNC. If there are less than 54 characters between DLE SYNC sequences, the line will lose its link protocol synchronization and loss of data will occur. SYNC-idles are inserted in the message for timing purposes only, and have no effect on the message format.

25.8.2 Receive Timeout. This is a nominal 3-second timeout and is used as follows:

a. Limits the waiting time tolerated for a transmitting station to receive a reply.

b. Permits any receiving or monitoring station to check the line for SYNC-idle signals. These SYNC-idles indicate that the transmission is continuing; thus, this timeout is reset and restarted each time a SYNC-idle is detected.

25.8.3 Disconnect Timeout. This timeout is used optionally on switched network data links. It is a nominal 20-second timeout used to prevent a station holding a connection for prolonged periods of inactivity. After 20 seconds of inactivity, the station will disconnect from the switched network.

25.8.4 Continue Timeout. This is a nominal 2-second timeout associated with the transmission of TTD and WACK. The continue timeout is used by stations where the speed of input devices (for transmitting stations) or output devices (for receiving stations) affect buffer availability and may cause transmission delays.

TTD is sent by the transmitting station up to 2 seconds after receiving acknowledgment of the previous block, if the transmitting station is not capable of sending the next transmission block before that time.

A receiving station must transmit WACK to indicate a temporarily not-ready-to-receive condition if it is not able to receive within the 2-second timeout. The purpose of the timeout interval is to permit the receiving station to send an appropriate affirmative reply immediately if it becomes appropriate within the interval.

25.9 LOSS OF SYNCHRONIZATION. Loss of synchronization will be determined by the reception of one 8-bit character of all zeros or all ones after character framing has already been established. Under these two conditions the LCM will immediately return to a waiting-for-input condition.

25.10 STANDARD CODE. The AUTODIN II system design provides for Mode IB subscribers to use an 8-bit, odd parity ASCII code. The ASCII code is shown in Table IV and will have an added eighth bit to form odd parity on each character. Parity code conversion on output lines will be matched to the ANSI standard.

25.11 LINE CONTROL MODULE (LCM) - LINE TERMINATION UNIT (LTU) REQUIREMENTS. Mode IB communication lines will be terminated in a synchronous LTU which, in turn, will be connected to an LCM microprocessor. Mode IB LTU's will terminate and control the operation of full-duplex, synchronous communication lines using point-to-point procedures. Mode IB utilizes 8-bit ASCII with seven bits used for data plus one odd-parity bit. Odd parity is maintained for all data, control, and block framing characters.

The interface of these communication lines is through a time-division multiplexer (TDM) which, in turn, interfaces the TDMI LCM on a bit serial, character multiplexed data stream. A ninth bit with each character is exchanged between the TDMI LCM and

the TDM for providing TDM control and line control over and above the Mode IB protocol. This bit, when set to a one, indicates TDM control is contained in the following eight bits. This bit, when set to a zero, indicates valid data or control information is buried within the protocol and is to be exchanged between the node and the terminals.

The LTU will interface with the LCM via a bit parallel interface and convert the data to a serial bit stream on output. The least significant bit of the data will be serialized first and the parity bit position serialized last. Incoming serial data will be packed into a byte or word format prior to transfer to the LCM.

Mode IB data are formatted into blocks of variable length text data, with leading and trailing control characters framing this text data. Refer to paragraph 25.12 for Mode IB Data Formats. The final character of a block is a BCC, which is used for error control. The first character of a block is a SOH or STX. Receipt and recognition of SOH or STX will trigger the BCC accumulation for the block. The LTU/LCM will recognize the leading and trailing control characters. On input, recognition of the SOH/STX will start the text data transmission to the TAC. Detection of ETX or ETB will cause the BCC check to occur. The LCM will notify the TAC of block message completion by causing the appropriate status and interrupt to be generated. On output, these control characters will cause the appropriate actions in the opposite directions.

The maintenance of data and control character integrity requires proper synchronization between the transmitting and receiving elements of the communication path between the terminals. The synchronous channel card (SCC) in the TDM will maintain this synchronization in conjunction with commands from the KMC-11B/DMS-11B. The transmitter will precede all blocks of data with a minimum of four consecutive ASCII SYNC characters. The receiver will recognize two consecutive SYNC characters to synchronize itself. SYNC characters will not be forwarded to the TAC; however, an indication that the SCC is receiving synchronization will be available to the LCM for status reporting purposes. Synchronization will also be transmitted during the idle link state in the absence of data.

All Mode IB characters have odd parity. Once synchronization has been established, the LTU will check and flag any character received with even parity as an error and forward this condition to the LCM.

At the end of each transfer and upon request, a status word will be returned to the TAC processor. The status word will indicate the status of the lines.

25.12 MODE IB DATA FORMATS. Figure B-4 shows the Mode IB data formats that will be used in AUTODIN II. The following items are illustrated in these figures:

a. Initialization and One Way Operation

b. Control Character ENQ - Enquiry

c. Control Character NAK - Negative Acknowledgment

d. Control Character WACK - Wait Before Transmit Positive Acknowledgment

e. Control Character RVI - Reverse Interrupt

f. Control Character ITB - End of Intermediate Transmission Block

g. Control Character TTD - Temporary Text Delay

h. Timeouts

i. Half-Duplex Data Transmission (Two Way Alternate)

25.12.1 Heading. The heading is a block of data starting with SOH and containing one or more characters that may be used for message control, eg, message identification, routing, priority and security). SOH initiates the block-check-character (BCC) accumulation. The SOH is not included in the accumulation. The heading is ended with ETB followed by BCC as illustrated in Figure B-4.

The heading can be terminated prematurely by use of the ENQ (indicating disregard the block) without the ETB and BCC. The receiver will reply with a NAK and the heading will be retransmitted. This is illustrated in Figure B-4C., Control Character NAK - Negative Acknowledgment.

The Mode IB heading data is in accordance with the THP command procedures described in Section 27.

25.12.2 Text. The text data is the most significant portion of the transmission. It is transmitted in complete units called messages, which are initiated by STX and concluded with ETX. Each message is a complete unit that can stand alone and is not necessarily directly related to other messages being transmitted. A message can be subdivided into smaller blocks for ease in processing and more efficient error control. Each block starts with STX and ends with ETB (except for the last block of a message, which ends with ETX). A single transmission can contain any number of blocks (ending with ETB) or messages (ending with ETX). An EOT following the last ETX block indicates a normal end of

transmission. Message blocking without line turnaround can be accomplished by using ITB (see paragraph 25.6.5 and Figure B-4F, Control Character ITB - End of Intermediate Transmission Block).

Control characters or sequences within a block of text are not allowed. Any station receiving a control character within a text block treats the control character or sequence as data and waits for the block check character (BCC) to detect a possible error. If an error is detected, normal recovery procedures are used. If no error is detected, the transmission is treated as valid data.

A block of text data can be terminated prematurely by using an ENQ character, which signals the receiver to "disregard this block". NAK is always the reply in this situation, since the block ended with a forced error condition. An example is shown in Figure B-4C, Control Character NAK - Negative Acknowledgment.

25.13 SWITCHED-NETWORK (DIALUP) OPERATION. For switched-network operation, the point-to-point connection can be established by either manual or automatic means. At the PSN the call will be answered automatically by TCMS. Dialed connections are operated as point-to-point lines with contention. Both stations start in the "circuit-assurance mode". Once circuit assurance is established and identified, the stations use the normal BCS procedures required for operation (switched point-to-point). When both stations have completed their message transmissions, a disconnect signal is normally sent.

The "circuit-assurance mode" is entered when the called station goes "off-hook". At this time the calling station is notified by a signal from its data set that a connection with another data set has been established. Once this indication is received, the calling station sends either of the following messages:

WRU - Who are you (the transmitted sequence is SYNC SYNC ENQ). This requests the called terminal to identify itself.

IAM/WRU - (the transmitted sequence is SYNC SYNC (ID) ENQ where ID = station identification sequence). This message identifies the calling station and requests the called station to identify itself.

Either message is then followed by an identification message from the called station as follows:

ID ACK0 - (the transmitted sequence is SYNC SYNC (ID) ACK0, where ID is optional).

NOTE

If the received ID sequence is unsatisfactory, then either station can initiate a disconnect sequence.

Additional signals available as a reply to the WRU or the IAM/WRU message are:

NAK - This indicates that a "not ready" condition exists at the called station.

WACK - (optional) This indicates that "temporary not ready to continue" condition exists at the called station.

Refer to Figure B-5 for Mode IB Switched - Network Dialup Operation.

All stations must provide the capability to transmit identification sequences in order to permit several stations to operate on the same switched line. An identification (ID) sequence can be from 2 to 15 characters long. The minimum 2-character sequence consists of the same character transmitted twice.

ID sequences may precede ENQ, ACK1, ACK0, and NAK in the control mode. A receiving station must be able to recognize the above control characters when preceded by an ID sequence. WACK must not be preceded by an ID sequence.

Both stations exit from the circuit-assurance mode following satisfactory initialization when any of the following sequences are sent or received:

a. SYNC SYNC EOT - Returns the data link to normal operation, control mode

b. SYNC SYNC SOH - Initiates a block of header data

c. SYNC SYNC STX - Initiates a block of text data

All signals other than those just described are considered to be errors. If a valid reply is not received by the calling station (following either a WRU or an IAM/WRU) within the receive timeout period, the request message can be retransmitted. However, the data link continues in the circuit-assurance mode until the circuit-assurance sequence is satisfactorily completed.

The call between stations can be terminated by the disconnect timeout or by transmission of the disconnect sequence: SYNC SYNC DLE EOT. This sequence may be initiated by either station when operating on a switched-network basis. When operating with a control station, the control station normally initiates the disconnect sequence. As this sequence is transmitted and received, each station returns to an on-hook condition and the line is dropped.

Although the switched network (dialup) operation is supported, the dialout is not permitted.

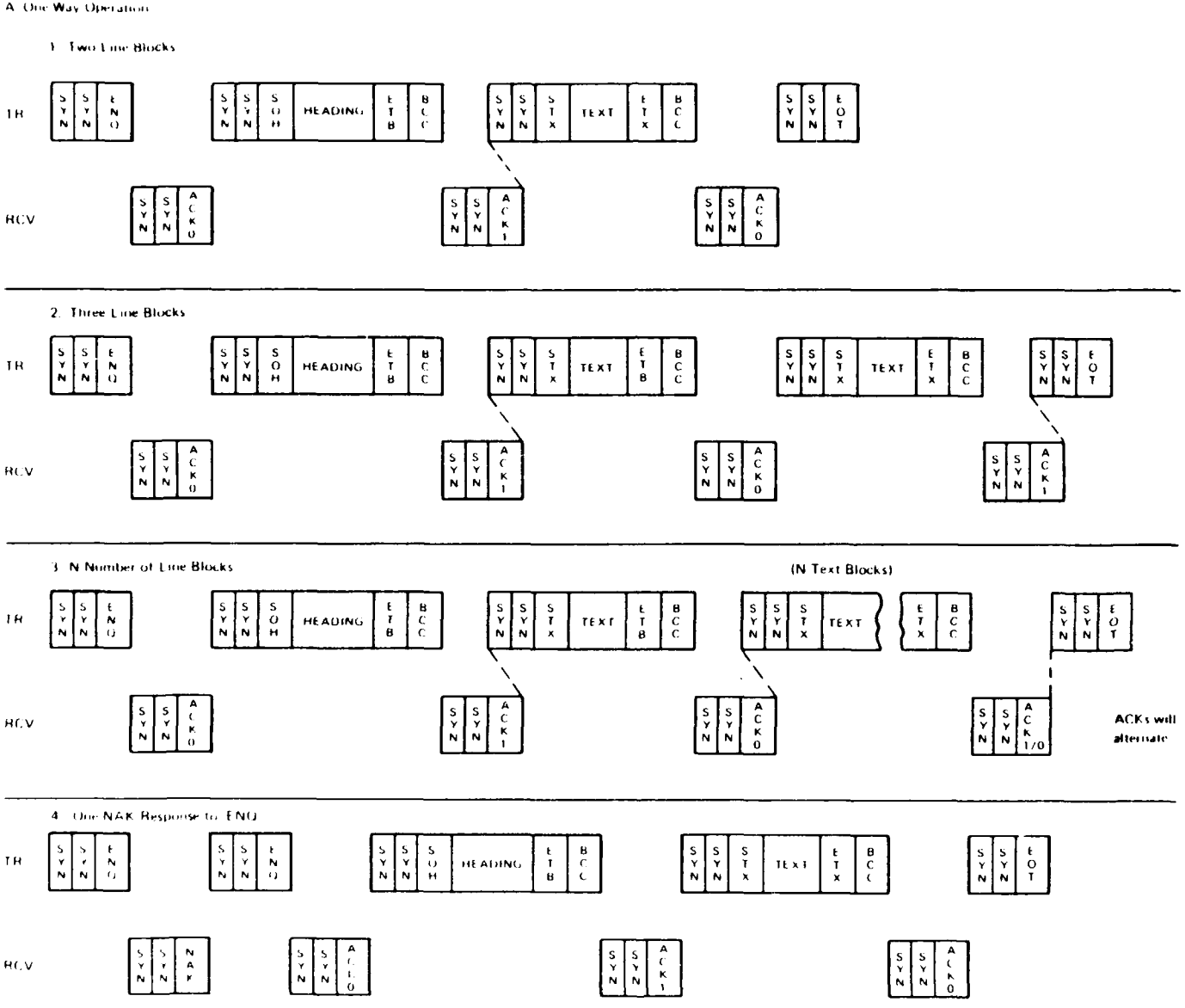


Figure B-4. Mode IB Link Protocols
(Sheet 1 of 11)

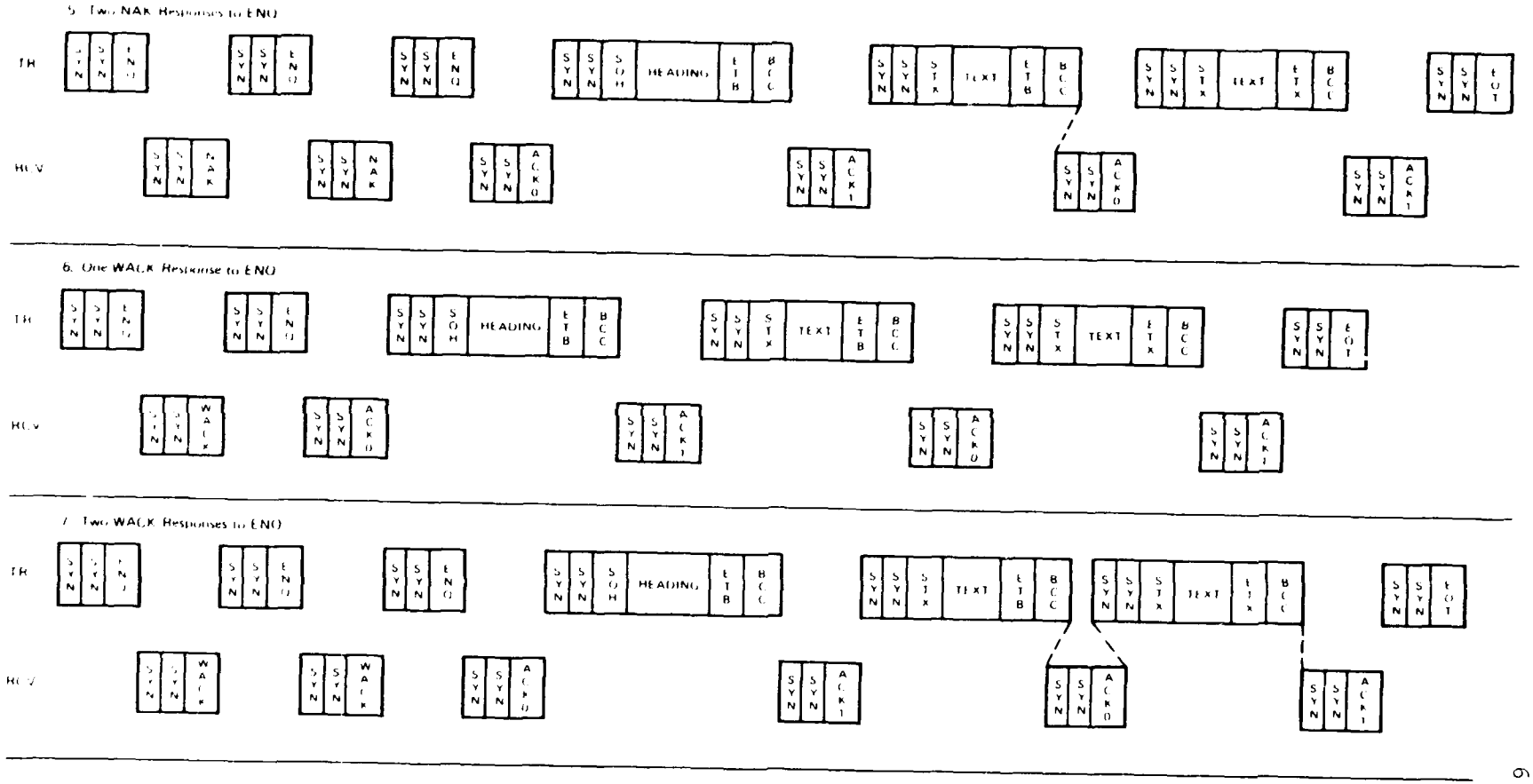


Figure B-4. Mode IB Link Protocols
(Sheet 2 of 11)

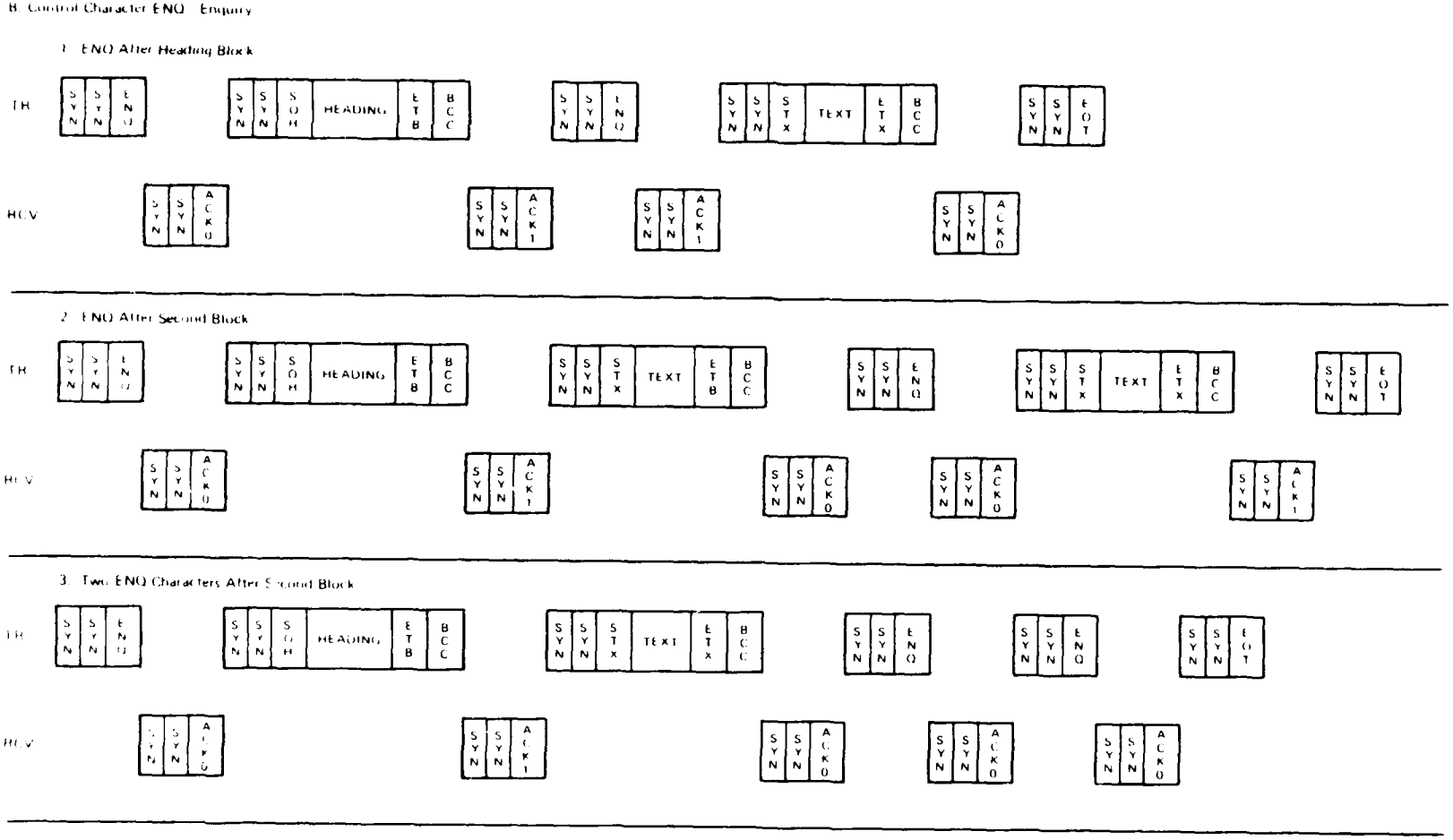


Figure B-4. Mode IB Link Protocols
(Sheet 3 of 11)

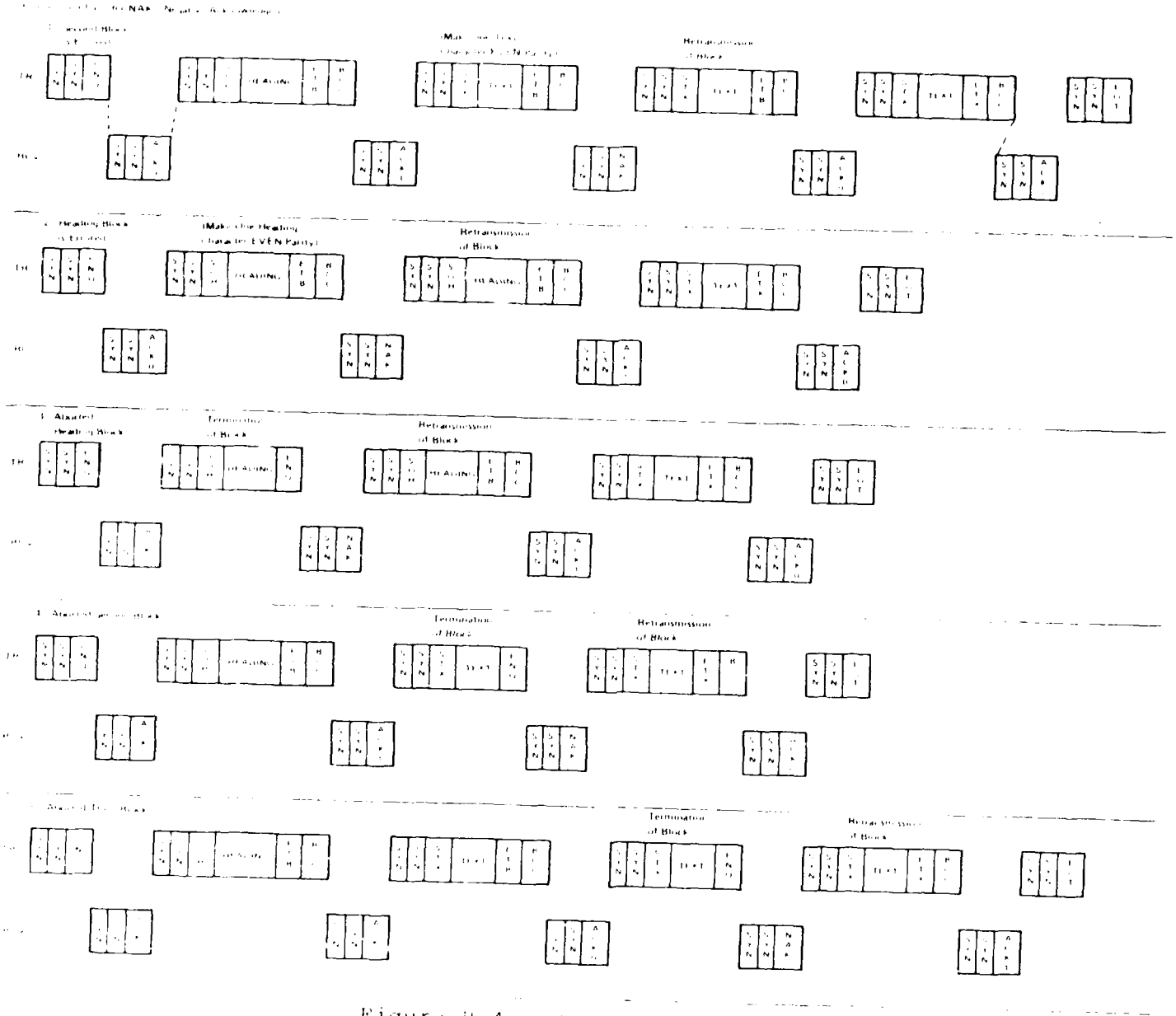


Figure B-4. Mode IB Link Protocols
(Sheet 4 of 11)

AD-A083 132 WESTERN UNION TELEGRAPH CO MCLEAN VA GOVERNMENT SYST--ETC F/G 17/2
COMPUTER PROGRAM DEVELOPMENT SPECIFICATION TERMINAL ACCESS CONT--ETC(U)
APR 79 DCA200-C-637

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END
DATE FILMED
5-80
DTIC

D. Control Character WACK -Wait Before Transmit Positive Acknowledgement

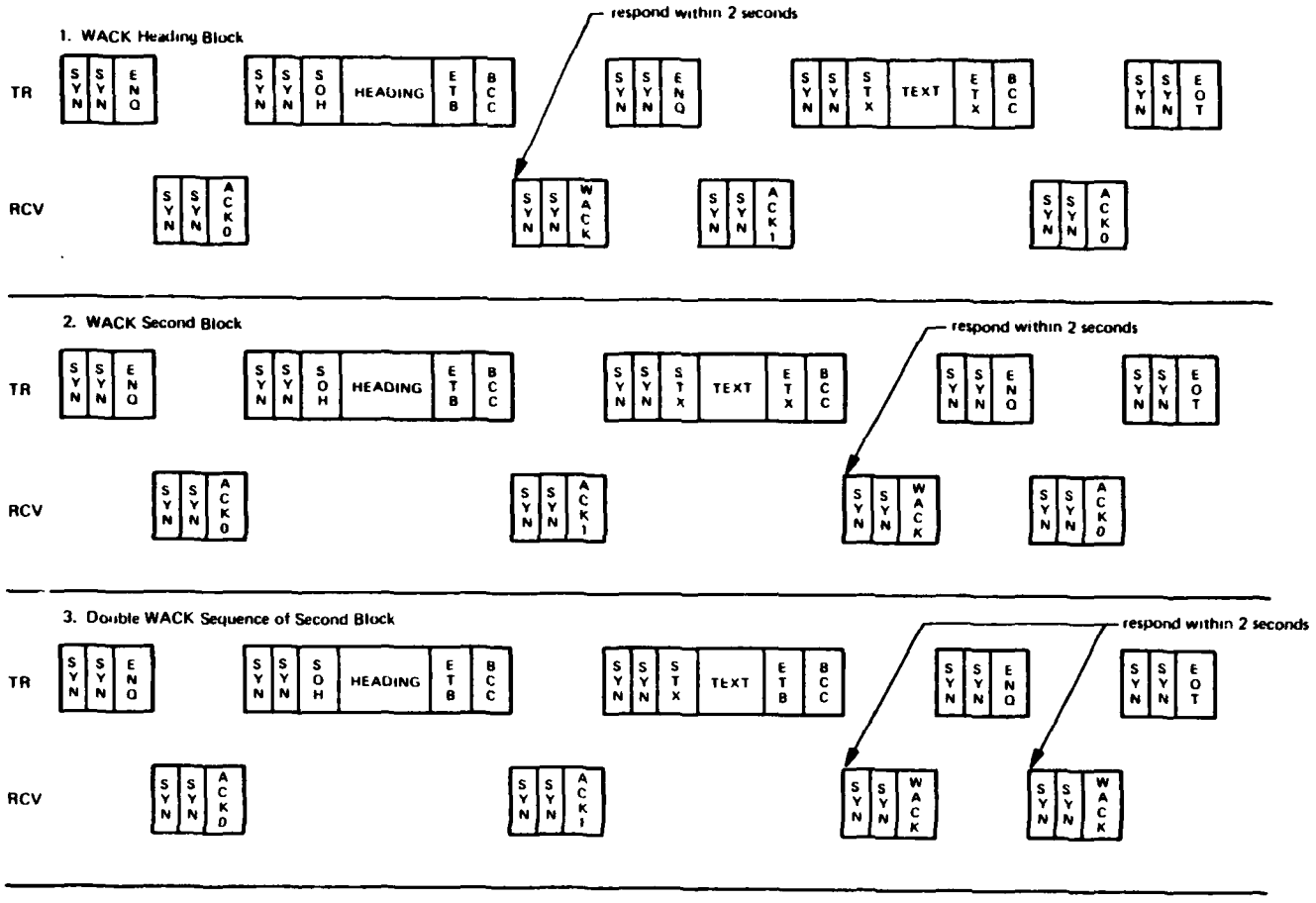


Figure B-4. Mode IB Link Protocols
(Sheet 5 of 11)

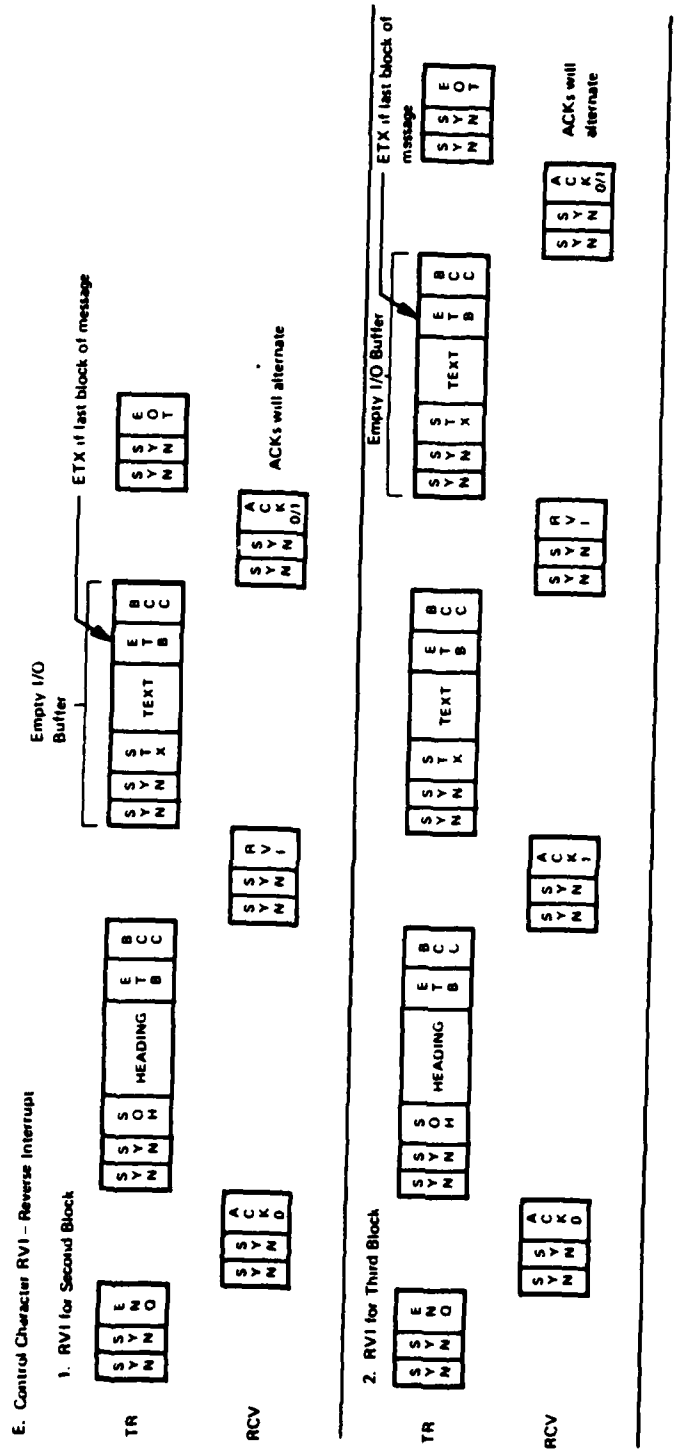
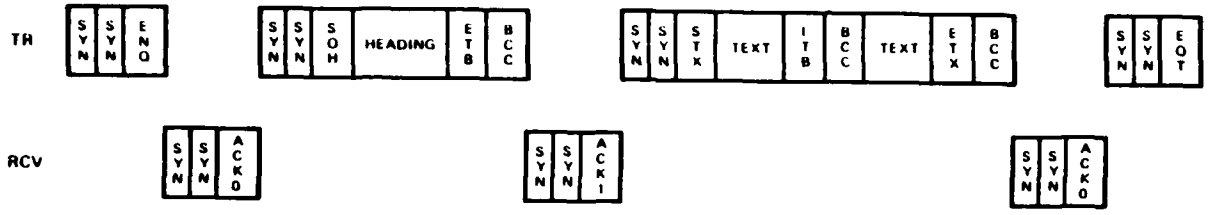


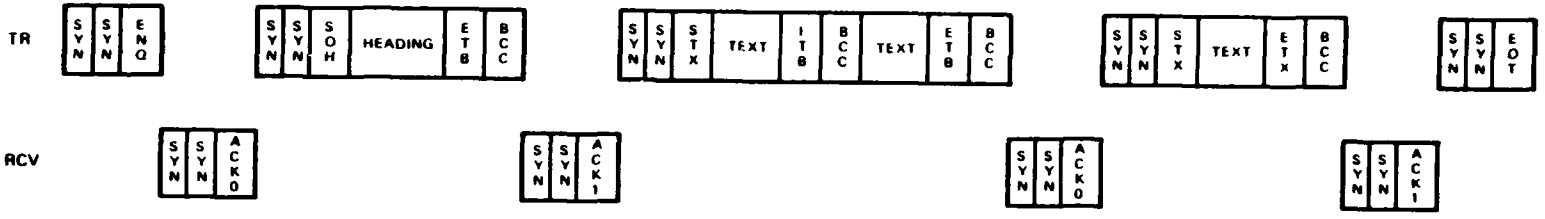
Figure B-4. Mode IB Link Protocols
(Sheet 6 of 11)

F. Control Character ITB End of Intermediate Transmission Block

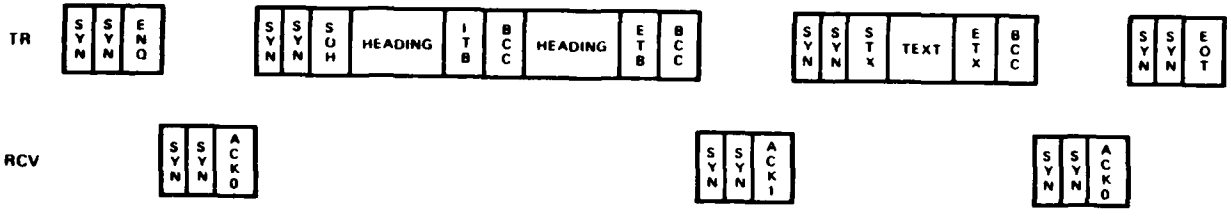
1. ITB in LAST Block



2. ITB in Second Block



3. ITB in Heading Block



4. ITB in Heading Followed by STX for Second Block

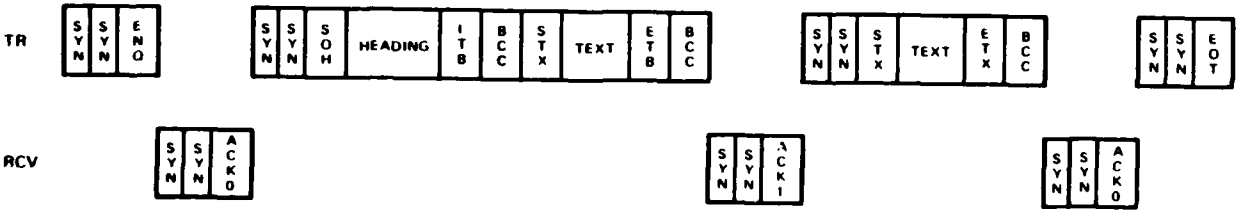


Figure B-4. Mode IB Link Protocols
(Sheet 7 of 11)

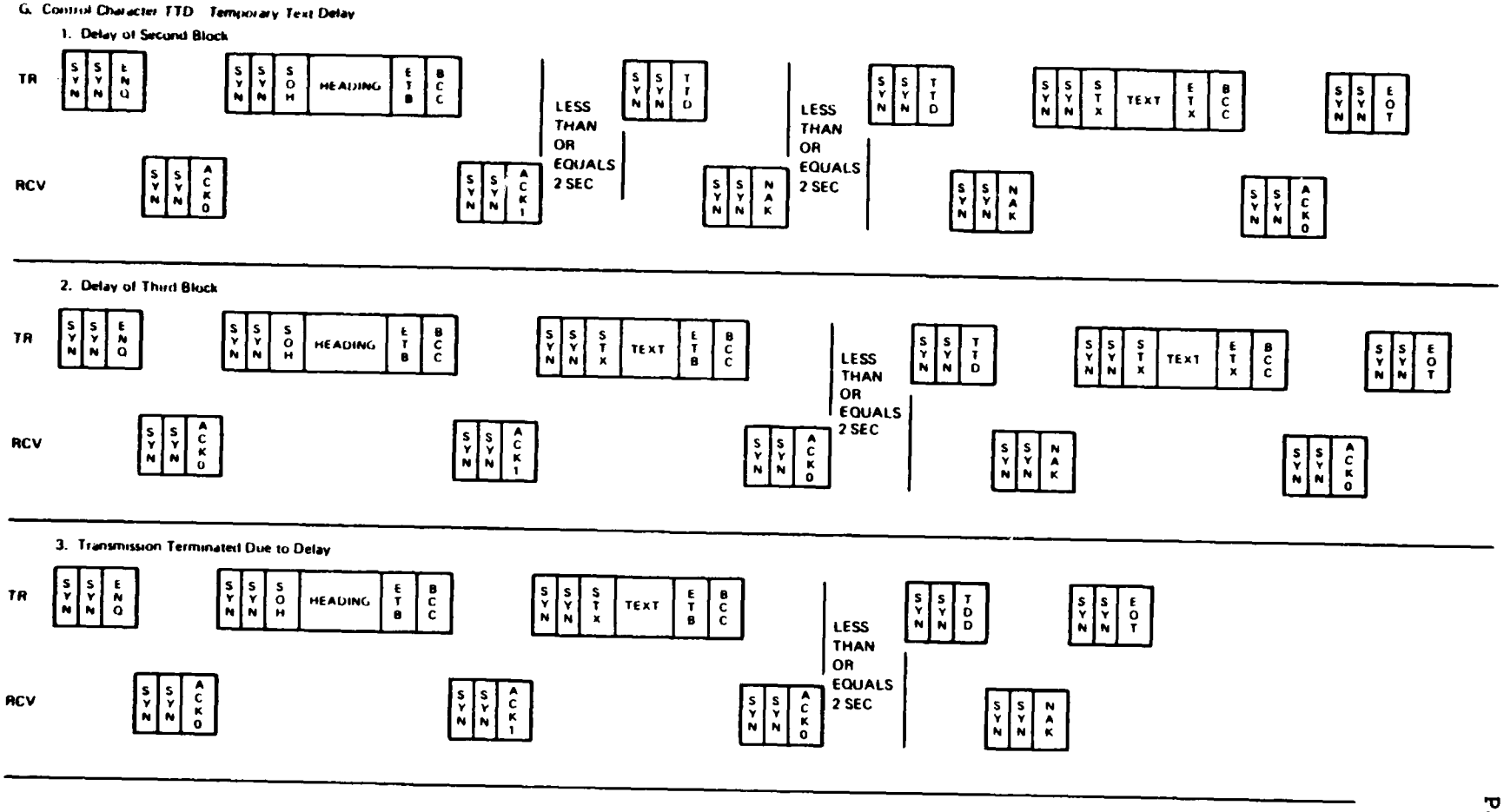


Figure B-4. Mode IB Link Protocols
(Sheet 8 of 11)

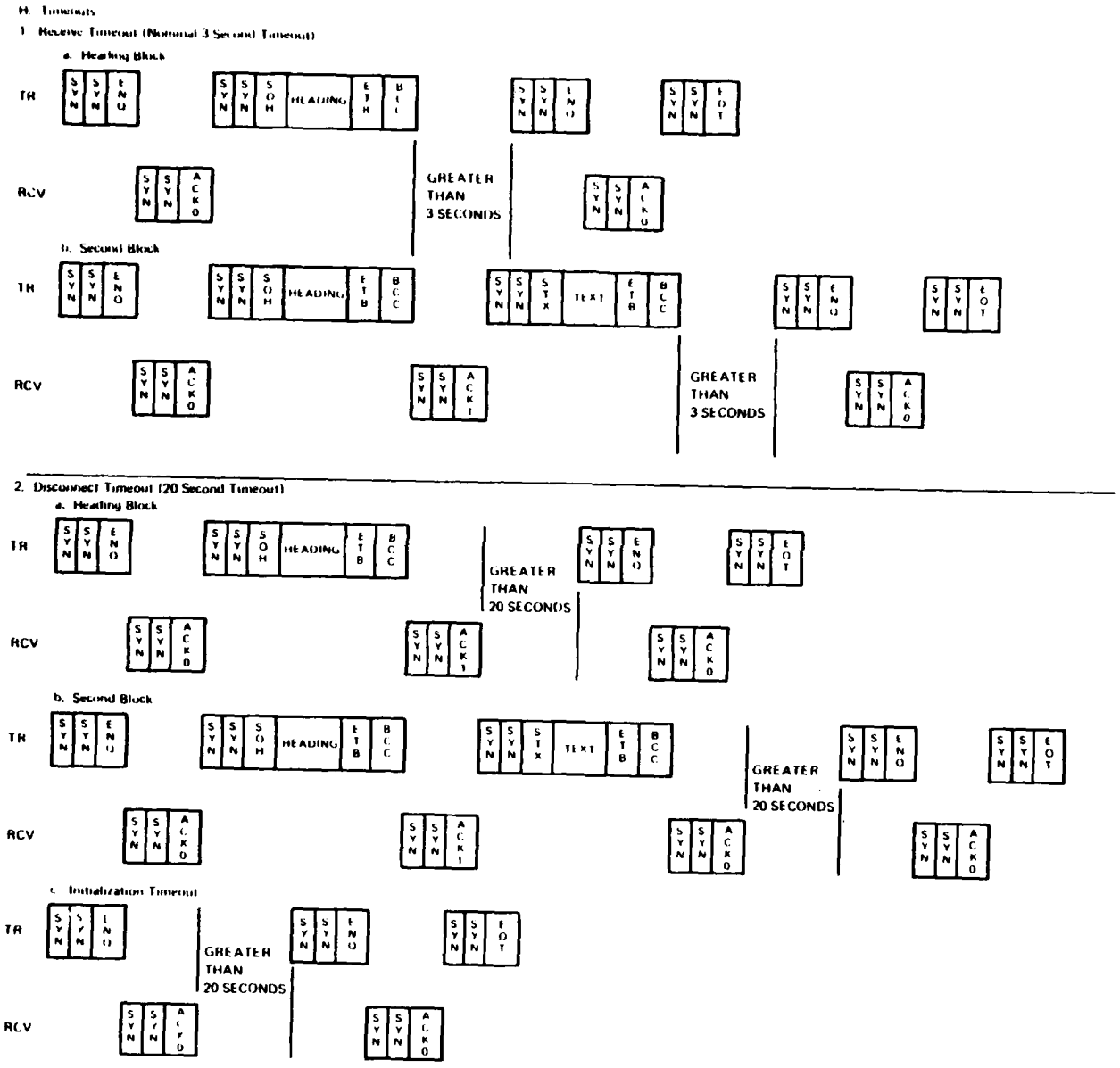


Figure B-4. Mode IB Link Protocols
(Sheet 9 of 11)

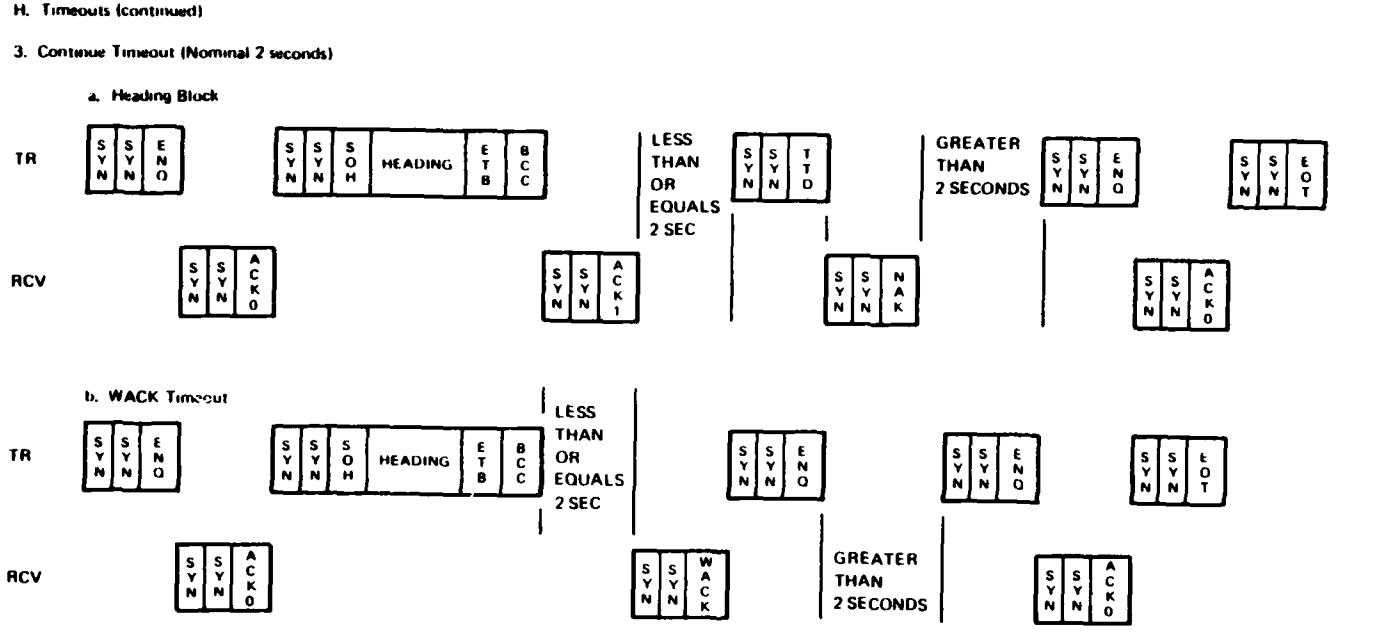


Figure B-4. Mode IB Link Protocols
(Sheet 10 of 11)

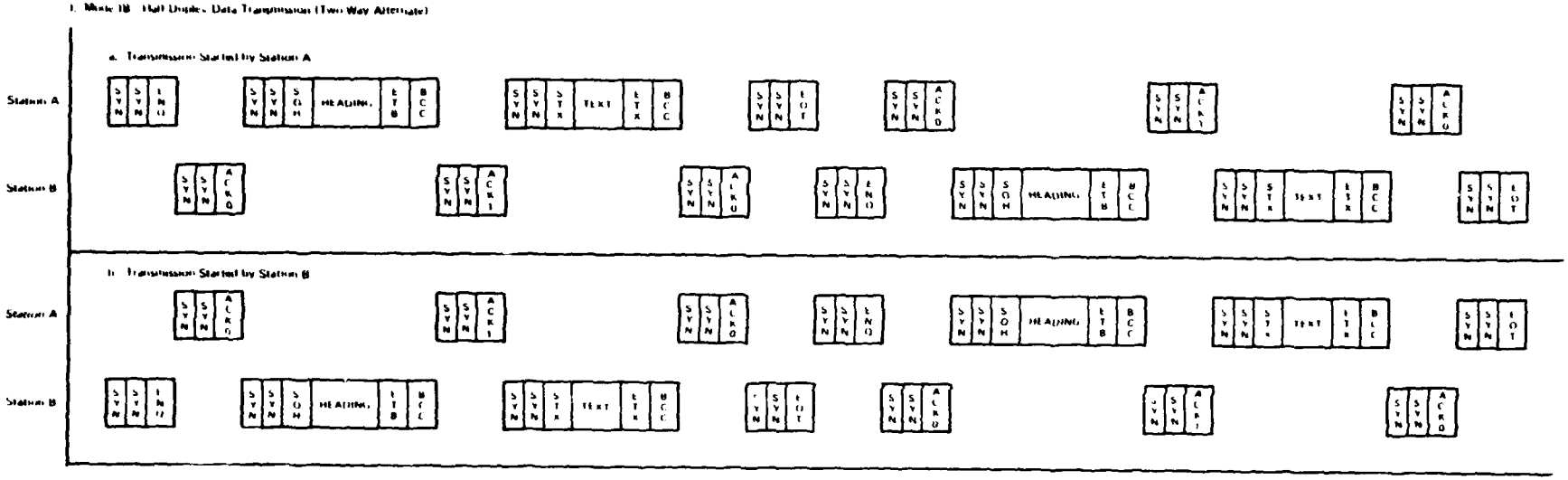


Figure B-4. Mode IB Link Protocols
(Sheet 11 of 11)

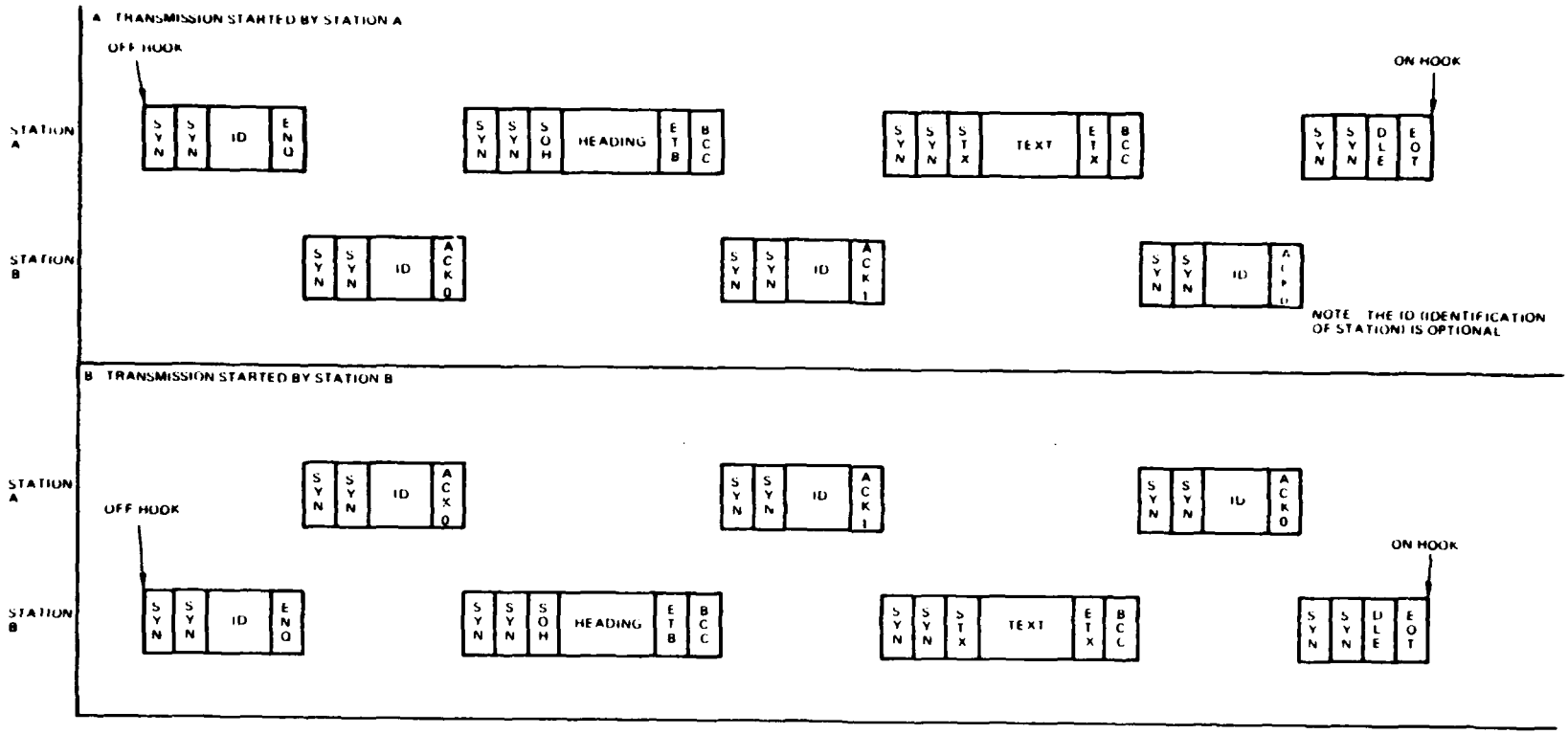


Figure B-5. Mode IB - Switched Network Dialup Operation

SECTION 26 - MODE IIA LINK PROTOCOL

26.1 INTRODUCTION. Mode IIA is a character asynchronous half or full duplex type of operation with no automatic error detection or error correction capabilities. Synchronization of the end devices is achieved through the START and STOP elements of the code. Mode IIA is used on subscriber access lines using the 10 or 11 unit asynchronous American Standard Codes for Information Interchange (ASCII). A character in asynchronous ASCII is composed of one start bit, seven information bits, one parity bit, and, depending on system requirements, one or two stop bits. Echo capability is used on those full-duplex lines that do not have an Interface Control Unit (ICU). Paragraph 26.8, Figures B-6 and B-7, illustrate half and full duplex Mode IIA operation.

26.2 APPLICABLE DOCUMENTS

a. DCAC 370-D175-1 - DCS AUTODIN Interface and Control Criteria dated 2 October 1970, Chapter 1, paragraph 4.b.

b. FIPS PUB 1 - Federal Information Processing Standards Publication 1 - Standard Code for Information Interchange, 1 November 1968.

26.3 LINK CONTROL STRUCTURE AND DISCIPLINE. The network provides transmit only for the traffic of Mode IIA subscribers. There is no service provided for error recovery, acknowledgment, or handling of other exception conditions between AUTODIN II and the subscriber. The responsibility for the integrity of Mode IIA and recovery from exception conditions rests with the subscribers.

26.4 TIMING AND SYNCHRONIZATION. The system design assumes that timing and synchronization for Mode IIA subscribers will be derived from the modem or a Crypto Ancillary Unit (CAU) if they are encrypted. The code used in Mode IIA provides start and stop bits for synchronization of the subscriber and devices. The CAU's will furnish timing on the line side if encrypted.

26.5 LINE CONTROL MODULE (LCM) - LINE TERMINATION UNIT (LTU) REQUIREMENTS. All Mode IIA asynchronous communication lines will be multiplexed and terminated in a synchronous LTU which, in turn, will be connected to an LCM microprocessor. The LCM microprocessor will be programmed to process the asynchronous characters.

The interface of these communication lines is through a Time Division Multiplexer (TDM) which, in turn, interfaces the Time Division Multiplexer Interface (TDMI) LTU on a bit serial, character-multiplexed data stream. A ninth bit is exchanged between the TDMI LTU and the TDM to provide TDM control and line

control over the Mode IIA protocol. When set to a one, this bit indicates valid data or control information that is buried within the protocol and, therefore, is to be exchanged between the node and the terminals.

In the receive mode, the TDM will detect the start and stop framing elements of each character, strip them, and transfer the data character in aggregate format to the TDMI LCM. Even parity will be detected in the TDMI LCM for each character.

Upon detecting an error, detecting a special character, or detecting the termination of a message, a status word will be placed in the interrupt queue to notify the TAC.

In the transmit mode, the LTU will accept 8-bit characters from the LCM and convert them to a serial bit stream starting with least significant bit. Start and stop bits are inserted by the TDM.

The features implemented by Mode IIA and IIAH LTU's and LCM microprocessor are:

a. Full-duplex operation for Mode IIA and half-duplex operation for Mode IIAH

b. If even parity, converted to odd while transferring to main memory

c. Program selection of automatic echo

d. If parity error on a character, substitute asterisk (*)

26.6 STANDARD CODE. The system provides code conversion to match the parity requirements for synchronous and asynchronous subscribers. The standard code used with Mode IIA subscribers will be asynchronous ASCII with 10 or 11 bits per character. Refer to Table B-VI for the ASCII code. Each data character will have one start bit, seven information bits, one parity bit (ANSI even parity), and one or two stop bits, depending on system requirements. Parity code conversion on output lines will be matched to the American National Standards Institute (ANSI) standard.

26.7 MODE IIA INTERFACE CONTROL UNIT (ICU). The ICU is an electrical device optionally provided at Mode IIA outstations to interface and control data terminal equipment (DTE). Electrically, the ICU fits between the DTE and the security device (crypto is equipped with a CAU) in a secure installation or between the DTE and data circuit termination communication equipment (DCE) in a nonsecure installation. All data and control lines between these areas will either terminate in the ICU or pass through the ICU to the other device.

Table B-VI. USASCII Character Assignments in Mode IIA

b_7 b_6 b_5 → / Bits b_4 b_3 b_2 b_1 / COLUMN / ROW	0_{0_0}	0_{0_1}	0_{1_0}	0_{1_1}	1_{0_0}	1_{0_1}	1_{1_0}	1_{1_1}
b_4 b_3 b_2 b_1	0	1	2	3	4	5	6	7
0 0 0 0	0	NUL	DLE	SP	0	@	P	`	p
0 0 0 1	1	SOH	DC1	!	1	A	Q	a	q
0 0 1 0	2	STX	DC2	"	2	B	R	b	r
0 0 1 1	3	ETX	DC3	#	3	C	S	c	s
0 1 0 0	4	EOT	DC4	$	4	D	T	d	t
0 1 0 1	5	ENQ	NAK	%	5	E	U	e	u
0 1 1 0	6	ACK	SYN	&	6	F	V	f	v
0 1 1 1	7	BEL	ETB	'	7	G	W	g	w
1 0 0 0	8	BS	CAN	(	8	H	X	h	x
1 0 0 1	9	HT	EM	)	9	I	Y	i	y
1 0 1 0	10	LF	SUB	*	:	J	Z	j	z
1 0 1 1	11	VT	ESC	+	;	K	[	k	{
1 1 0 0	12	FF	FS	,	<	L	\	l	|
1 1 0 1	13	CR	GS	-	=	M	]	m	}
1 1 1 0	14	SO	RS	.	>	N	^	n	~
1 1 1 1	15	SI	US	/	?	O	_	o	DEL

26.3 MODE IIA DATA FORMATS. Figures B-6 and B-7 illustrate Mode IIA half- and full-duplex operation. The heading data is in accordance with the THP command procedures described in Section 27.

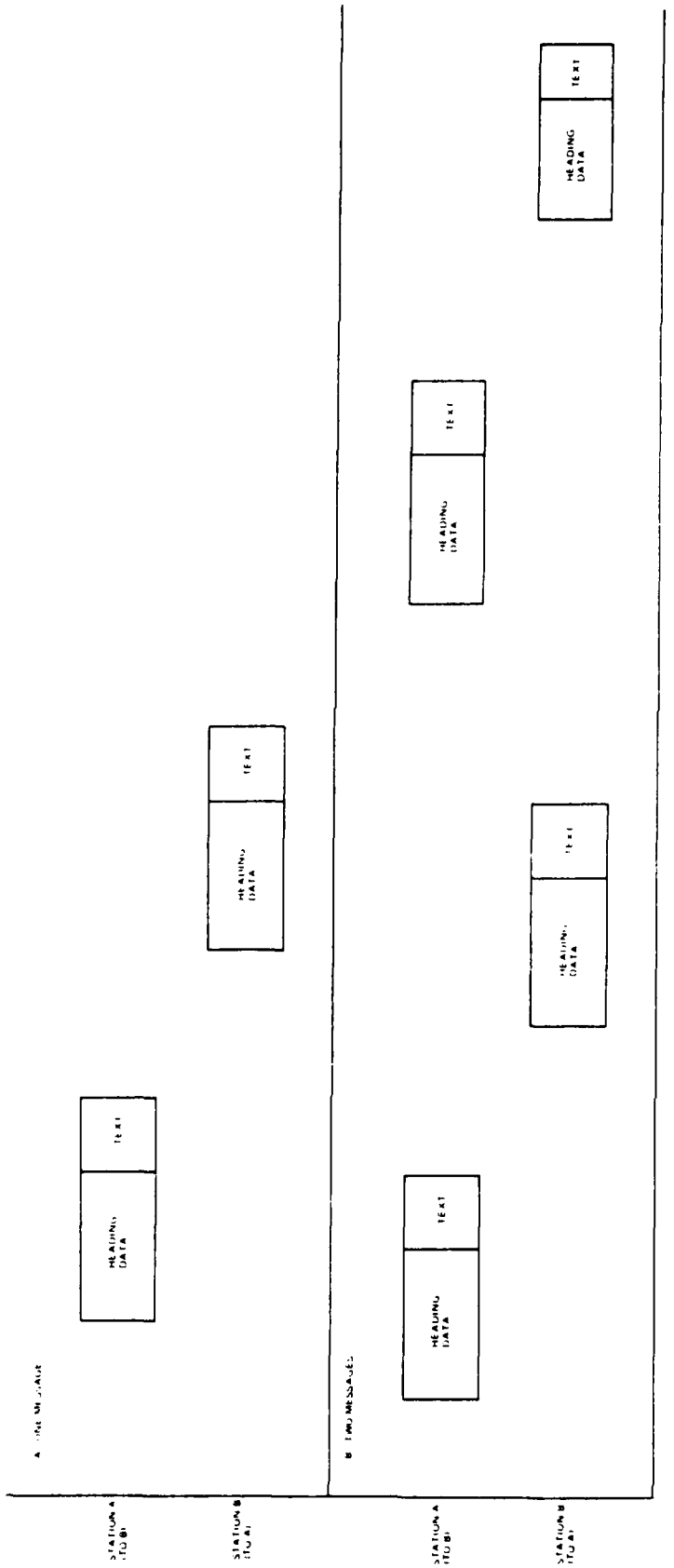


Figure B-5. Mode IIA Link Protocol - Half-Duplex Operation

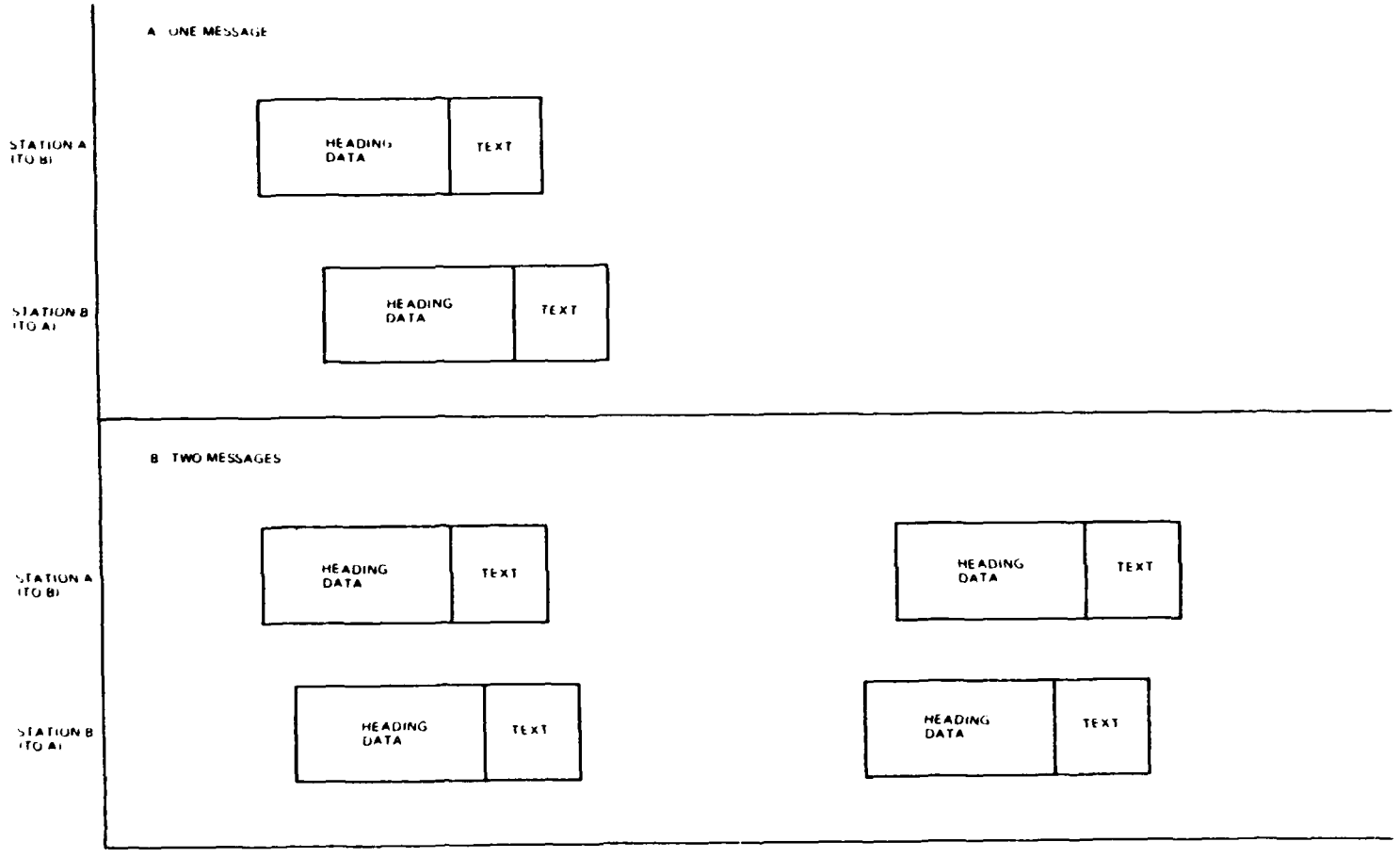


Figure B-7. Mode IIA Link Protocol - Full-Duplex Operation

SECTION 27 - THP COMMAND PROCEDURES

THP command procedures as defined in the Final Computer Program Development Specification for MCCU THP, CDRL Item Number B006, shall be used for the heading data for terminal access in Modes I, IB, IIA, and VI.